POWER

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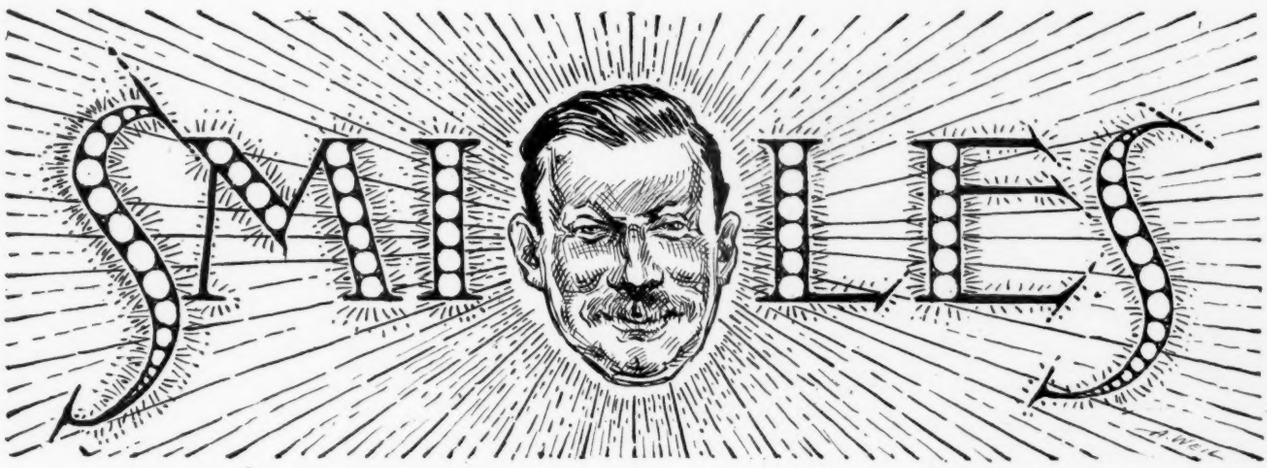


ENGINEERS of course fully realize the value of lubrication. They would not attempt to run or allow their subordinates to keep in operation any piece of machinery that was not kept properly oiled. Yet in their daily lives and conduct, engineers-in-charge do not seem to realize the lubricating value of a smile. Brought up in the rough school of practice, by the time they have arrived at a position of authority a great many seem to have completely lost their sense of humor.

Looking backward after nearly a score of years of power-house work, I remember four men who seem to stand out, apart from the rest. The first and most successful of these had the gift or acquired the ability of mixing a smile with his daily contact with those over whom he had authority. From a technical viewpoint, I believe this man knew the least of the quartet, yet he was one of the most successful engineers that I have ever known. Perhaps he appreciated the human element a little more than the others and acted accordingly. His engine room and boiler room were neat and clean, and he was always able to get the hard, hot and laborious work done without friction with his subordinates. He was not a loud-voiced individual, neither was he a wooden Indian, but he had the happy faculty of smiling at the right time.

In the last fifteen years this man has been the engineer-in-charge in four different plants and he has had the same degree of success in each. It may be he possessed a certain amount of personal magnetism that made the pathway easy, but I am convinced that for the most part it was simply because he could smile with his men when occasion demanded it.

The second of these four men has been in charge of some large plants and is a thorough mechanic as well as a first-class engineer, that is, a first class engineer, judging him from his knowledge of power-plant equipment and its needs. A martinet for discipline, he has always erected a barrier between himself and his men. When conditions have arisen that should have caused him to open the door of his reserve, he always bolted it securely from the other side.

This man, after a lifetime in power-plant work, cannot be called a successful engineer. Like the old Bourbons of France, he has learned nothing and forgotten nothing.

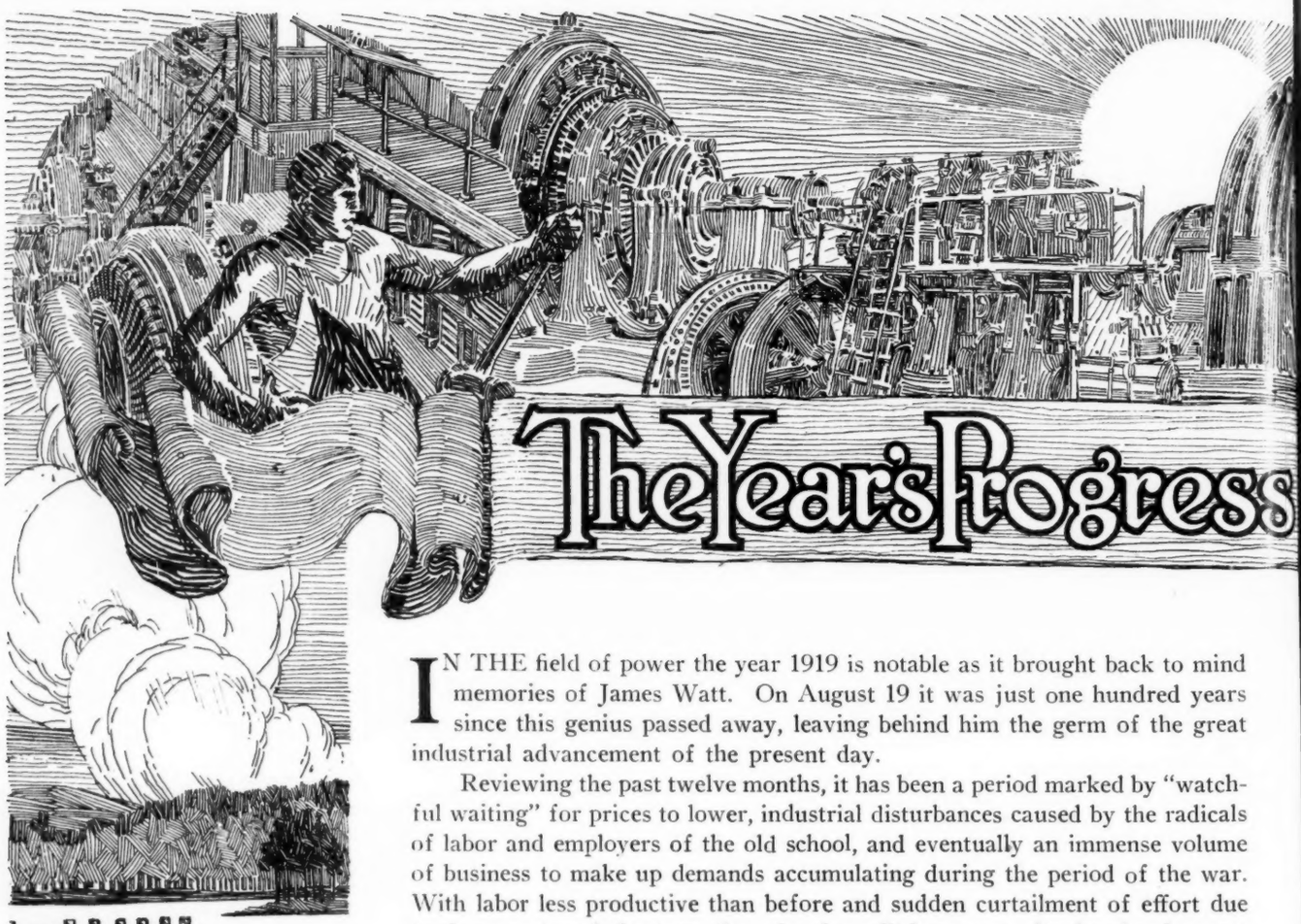
The third is a man of quiet demeanor and good intentions and a capable engineer in many ways, yet he evidently hasn't smiled since he was a child. It would actually be easier for him to cry than to crack a smile, and for that reason he is no more capable of inspiring a man to a little extra effort than the boiler-feed pump would be.

The last of the four has more technical knowledge than the rest and is a bright, keen man in every way, yet he has been the least successful of them all. A man of nervous temperament, not only is he easily irritated, but he conveys that irritation to others with the result that there is constant friction between himself and his help.

A distinguished artist was once asked by a young enthusiast with what he mixed his paints. The great man, noted almost as much for his gruffness as famed for his greatness, replied, "With brains, sir! Brains!" Applying this test to power-house work I believe if the successful engineer were asked to what he attributed his achievements, the reply would probably be: "By mixing my work with smiles, sir."

This line of reasoning could well be made to fit any branch of work, but we who go down to the pit of whirring wheels and humming drums of concealed energy, are prone to think of things that concern only us and to judge men and conditions by what we have learned from daily contact with life as we find it.

Contributed by Frankland Cheney.



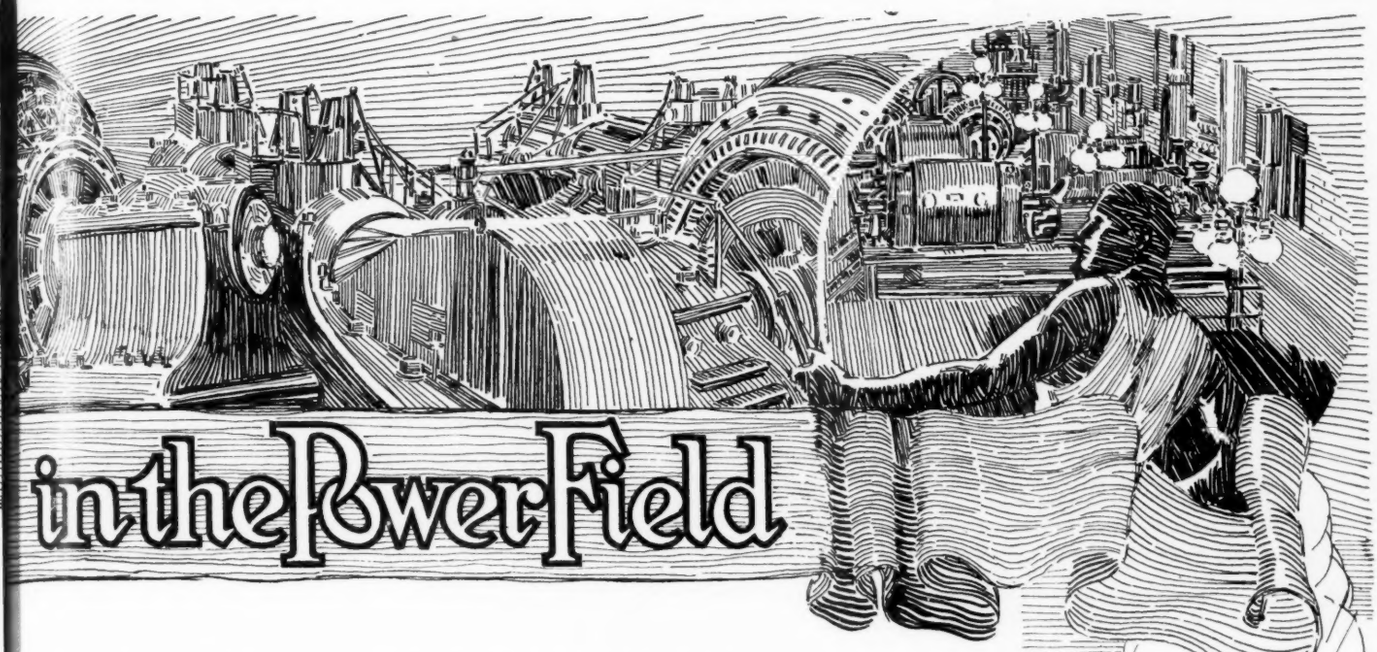
The Year's Progress

IN THE field of power the year 1919 is notable as it brought back to mind memories of James Watt. On August 19 it was just one hundred years since this genius passed away, leaving behind him the germ of the great industrial advancement of the present day.

Reviewing the past twelve months, it has been a period marked by "watchful waiting" for prices to lower, industrial disturbances caused by the radicals of labor and employers of the old school, and eventually an immense volume of business to make up demands accumulating during the period of the war. With labor less productive than before and sudden curtailment of effort due to the recent coal shortage, there has been little opportunity for development or even for special work of any kind. The big bulk of power equipment delivered has been along standard lines.

In engineering design it has been a period of crystallization. Operating results from high steam pressures and superheats are being weighed and digested, large turbines of different types are being compared, and designers are trying to settle in their own minds limits of speed and capacity. It is just a breathing spell, however, for the advancing cost of fuel makes action urgent.

As greater opportunities lie in higher pressures than in excessive temperatures, an early resumption of the advance in this direction may be expected. High pressures of yesterday are now standard, and a higher goal has been set. At no distant date the present maximum of 350 lb. gage coupled to a temperature approximating 650 deg. F. should be exceeded, with current practice following and slowly closing up the gap. Piping to carry pressures far above those now in common use is available, and welding will do considerable in eliminating leaks and similar troubles. Turbine designers do not anticipate insurmountable difficulties in building machines for any pressure that boilers will deliver. It is in the boiler itself, the economizer and the numerous auxiliaries of the plant that further investigation and development will be necessary. While boiler pressure might be increased to almost any desired point by the elimination of drums of large diameter, it is the steels now in commercial use that are the limiting factor. At about seven hundred degrees Fahrenheit the strength of the material seriously lessens, so that in operation it would be unsafe to exceed this temperature. More homogeneous material of higher heat-resisting qualities would solve the problem, but even the limit quoted would allow pressures up to six hundred pounds and low superheat, which in itself would give economies fifty per cent. greater than are obtained in present good practice, with due allowances, of course, for higher initial costs and probably higher upkeep resulting from the service. The ever-increasing price of coal has forced improvement in the average



in the Power Field

plant. The lessons taught by the Fuel Administration have not been forgotten. The possibilities of saving in the boiler room are more generally appreciated, and efficient combustion is being given more attention than ever before. Naturally, this has brought about a more general use of boiler-room instruments and by the manufacturer marked improvement in design, insuring greater accuracy and reliability.

Scarcity of coal as well as price has given impetus to the use of fuel oil, especially along the Atlantic coast; has brought about the use of inferior coals such as anthracite culm, coke breeze and lignites, and has stirred into renewed activity experimental work with powdered coal and colloidal fuel. Efforts toward conservation are turning more insistently to generation of electrical energy at the mines, to a more general use of water power and to the possibilities of low-temperature distillation of coal. Burning raw coal is extremely wasteful when it is possible to recover byproducts sufficient to pay for the fuel and still leave in the gas remaining, seventy per cent. of the original heat in the coal. Higher, but not excessive, initial cost of installation and more skilled attendance is the price of such recovery.

Scarcity of labor has enforced the installation of labor-saving devices in the power plant. The use of coal- and ash-handling equipment and of mechanical soot blowers has become more prevalent, and stokers cannot be made fast enough to meet the demand. The number of stoker manufacturers has increased at a surprising rate, and the capacity of each seems to be taxed to the limit. For the same reason and for the better economy that is possible, operators are resorting more frequently to automatic regulation of the damper, the supply of air to the furnace, the stoker engine and the water fed to the boilers.

High prices are also enforcing conservation along other lines. The profligate use of steel in the power-plant building, running as high as five to six pounds per pound of steam-generating capacity, is no more. The enormous heights above ground and depths below are giving way to more logical designs, inclosing only useful space, and economy in the use of construction material. A notable instance of this modern tendency is the new Moline boiler plant of the United Light and Railway Company. Reinforced concrete was used throughout with a considerable saving in first cost. A design studied to eliminate all but usable space and to combine bunker and roof support, was an additional factor in the economy.

A feature of the year was the remarkable activity among engineers. The characteristic reticence and retiring disposition of the average engineer gave way during the war to a realization of the value of coöperation and active

participation in public affairs. The result has been a desire for unification of effort among all engineering societies of the country. Plans of procedure have been remodeled and new services inaugurated to meet the new conditions. There has been a great movement toward coöperation between individual societies, and plans for amalgamation of engineering interests into one representative body, with the purpose of making more effective all work for the good of the public and the advancement of the profession.

Boiler Fuel

Briefly, the foregoing enumerates tendencies which require more illumination. Reverting to fuel, pulverized coal for the power plant has been in the spotlight again and notable improvement is evident. At Milwaukee the plant previously referred to in these columns has been extended and comprehensive tests have been conducted, but the results at this writing are not available for publication. Previous tests on the first unit were favorable, and encouraging word of equipment of this character comes from Seattle and Pittsburgh. At the spring meeting of the American Society of Mechanical Engineers the relative merits of powdered coal and modern stoker installations were given a thorough airing.

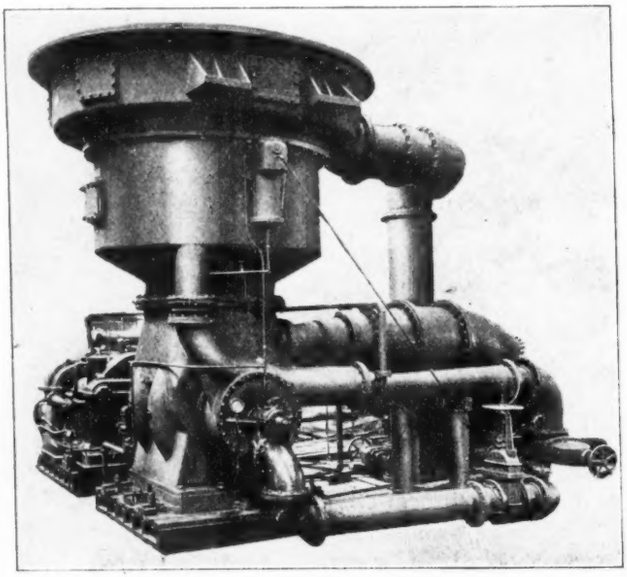


FIG. 1. WESTINGHOUSE JET CONDENSER, WILL PASS 13,000,000 GAL. OF WATER PER HOUR

Urgent need for coal conservation has again brought to the front the great piles of culm in the anthracite regions. The coarser portion of this fuel under proper conditions can be burned directly in stokers. The finer culm passing through a 1/32-inch mesh is first pulverized and, as powdered coal, has been burned successfully under boilers. Another interesting experiment was the mixing of this pulverized culm with oil in the proportions of thirty and seventy per cent., respectively. Similar tests on a mixture of coal and oil known as colloidal fuel were made with excellent results by the Submarine Defense Association with a view to conserving the oil supply of the Navy. In numerous instances anthracite screenings have been mixed with bituminous coal in about the same proportions as with oil and have been burned satisfactorily in hand-fired furnaces depending upon natural draft.

The rising price of coal and the shortage of labor has created a situation extremely favorable to oil. Where, formerly, regions remote from coal mines and contiguous to oil fields burned to advantage the latter fuel, quite recently there has been a steadily growing market for oil along the Atlantic coast, particularly in New England, which can be reached so conveniently by tank steamers. The movement is spreading to New York State, New Jersey and eastern Pennsylvania, and even in the bituminous coal regions of the Middle West there have been numerous transfers from coal to oil. The obvious reasons are the relative prices of the two fuels, the saving in labor effected by the use of oil and

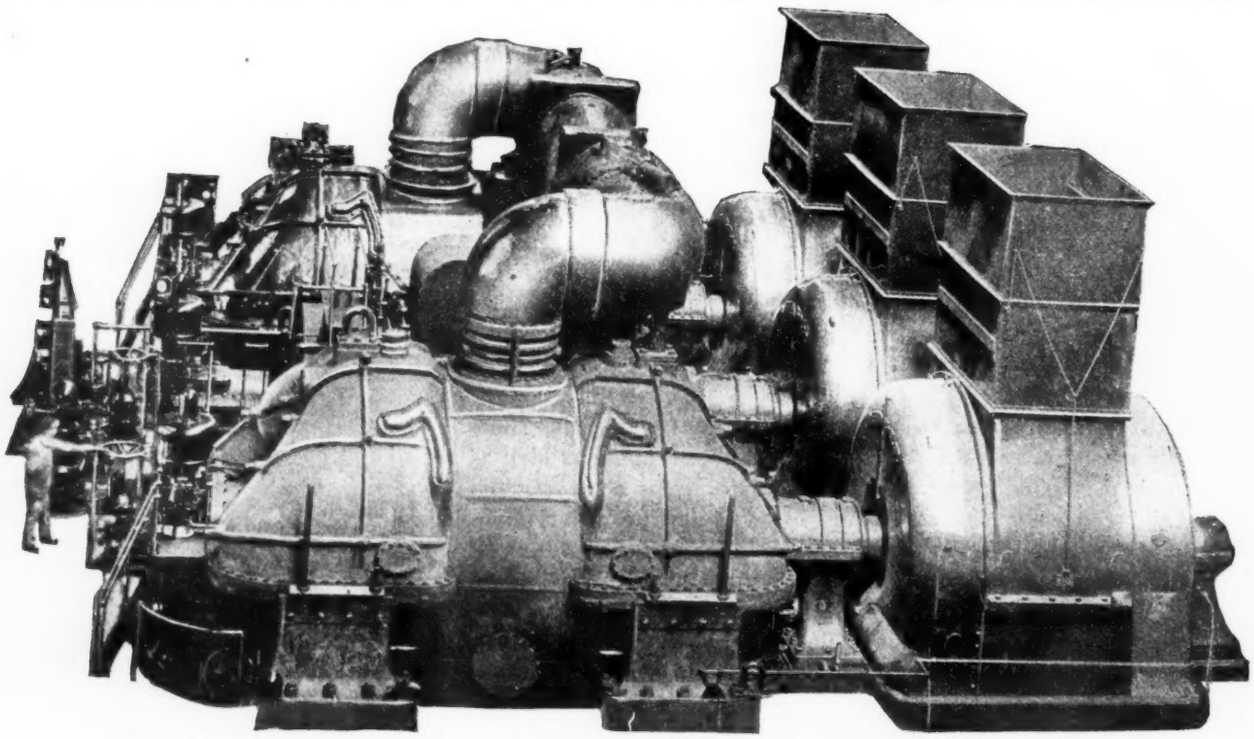


FIG. 2. WESTINGHOUSE 60,000-KV.-A. THREE-ELEMENT CROSS-COMPOUND TURBO ALTERNATOR

the more easily controlled combustion of the liquid fuel. Owing to the impetus given to the quest for petroleum during the war, the continued high prices for oil and the recent improved conditions in the market for drilling equipment, the domestic production for 1919 will reach probably 360 million barrels, as compared to 345 million barrels for 1918. The estimated consumption exceeds 400 million barrels, greater by a small percentage than the figure of 397 million barrels given for the previous year.

Mexico today is the great fuel-oil supply house. The 1919 production will likely be eighty million barrels; what the potential daily production is no one knows, but estimates by authorities place it at one million barrels. Oil interests are reported ready to spend one hundred million dollars in further developments there. The Mexican oil situation is now one of disputed ownership. In 1883 the Diaz government enacted the mining laws according to which the owner of the surface of oil-bearing land owned also the oil that the land might be made to yield. On these grounds the oil industry grew. At the constitutional convention of the Carranza government the famous "Article 27" of the constitution which became effective May 1, 1917, was written; it reads in part: ". . . the nation has direct dominion over . . . solid mineral combustibles, petroleum, and all solid, liquid or gaseous carbohydrates." Carranza, on Feb. 19 last, issued a statement defining the provision as meaning direct dominion. These decrees and others annulled the long standing previous legal status of all petroleum leases and titles.

But, however the dispute is settled, the price of oil will surely chase the price of coal. This is indicated by the fact that in New England consumers signed long-term contracts for oil at ninety-two cents per barrel of forty-two gallons, while today such contracts cannot be made under about $2.50 per barrel, and then there is a sliding-price clause which may be to the advantage or disadvantage of the cansumer.

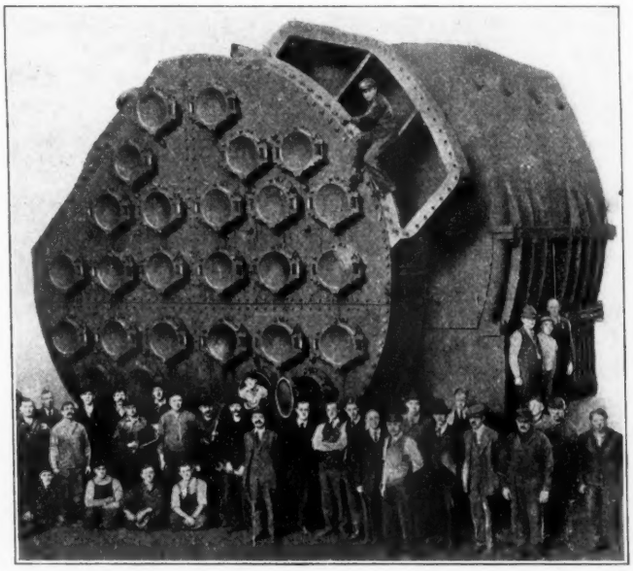


FIG. 3. WORTHINGTON SURFACE CONDENSER, 56,000 SQ. FT. OF ACTIVE TUBE SURFACE

Notable Steam-Power Plants

Among the notable steam stations given publicity during the year were the United States Nitrate Plant No. 2 at Muscle Shoals, Alabama, and the Old Hickory plant near Memphis, Tennessee, both war projects conceived and built in record time. The former, which was completed shortly after the armistice was signed, has never been in operation. It was laid out for two turbine units to supply ninety thousand kilowatts for the manufacture of great quantities of ammonium nitrate. Only one unit of sixty thousand kilowatts capacity was installed, this being a three-cylinder reaction turbine with a water rate ranging between ten and eleven pounds of steam per kilowatt-hour. Boilers were of the Stirling type having 15,070 square feet of steam-making surface and fifteen-retort underfeed stokers. Initially it

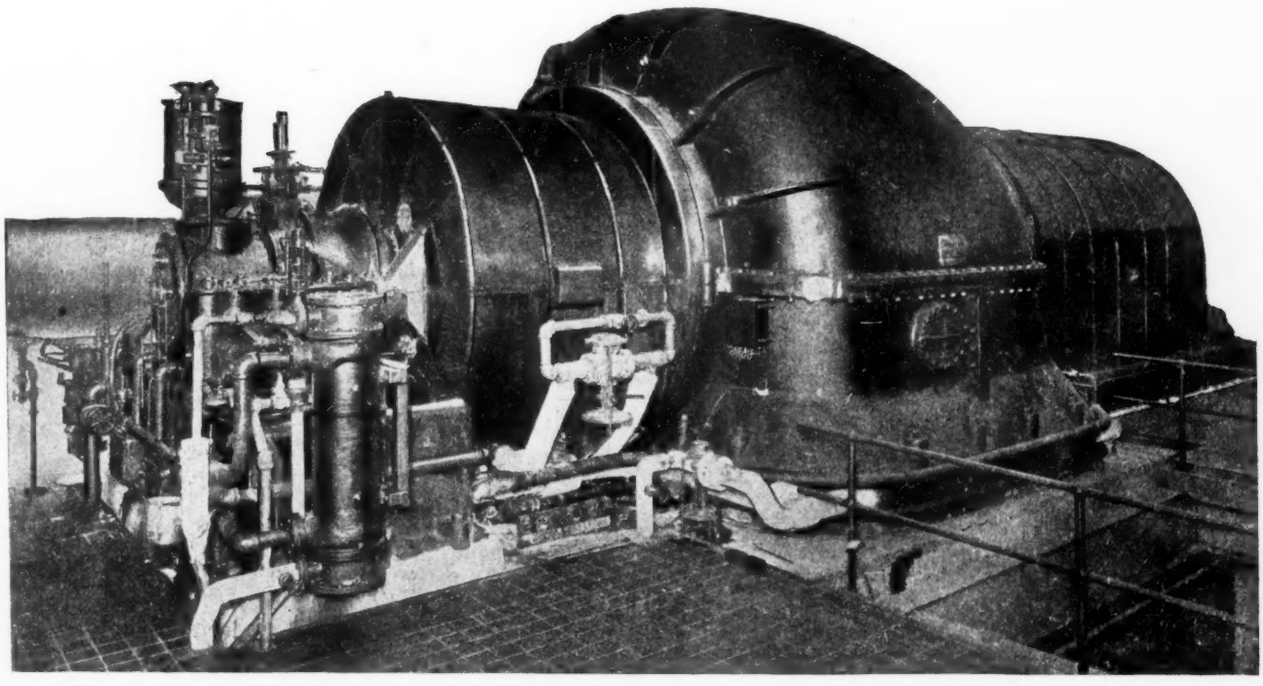


FIG. 4. GENERAL ELECTRIC 45,000-KV.-A. SINGLE CYLINDER TURBO ALTERNATOR

was planned to use a total steam temperature of 590 degrees. Operating conditions were to be practically ideal. Supplying principally electric furnaces, the load factor would have been ninety-five per cent. Excellent coal, low in ash and moisture and high in volatile, was available. With a furnace volume of 11.6 cubic feet per square foot of active grate area, a boiler efficiency ranging from 76 to 78 per cent. and a kilowatt-hour at the switchboard for seventeen to eighteen thousand British thermal units, was expected. Unfortunately, this plant has been shut down for nearly a year, waiting for the Government to decide what should be done with it.

At the Old Hickory plant are a large number of medium-sized boilers, sixty-eight of the Stirling type, rated at 823 horsepower each, having been installed. On the entire works over thirty-three thousand men were engaged in the construction. Everything was subordinated to speed and because of the probable short time of operation the cost was kept to the lowest possible point consistent with satisfactory operation. Boilers were installed on the basis of operation at 175 per cent. continuous rating and with the fifty-six thousand rated horsepower in boilers it was planned to carry day and night an average load of eighty-six thousand horsepower, this with Kentucky coal containing 14 per cent. ash, 1.8 per cent. sulphur and 12,600 B.t.u. per pound of dry coal. An estimated daily coal consumption of five thousand tons and about nine hundred tons of ash required an extensive system to store and handle, particularly as there was bunker capacity for only one day's run.

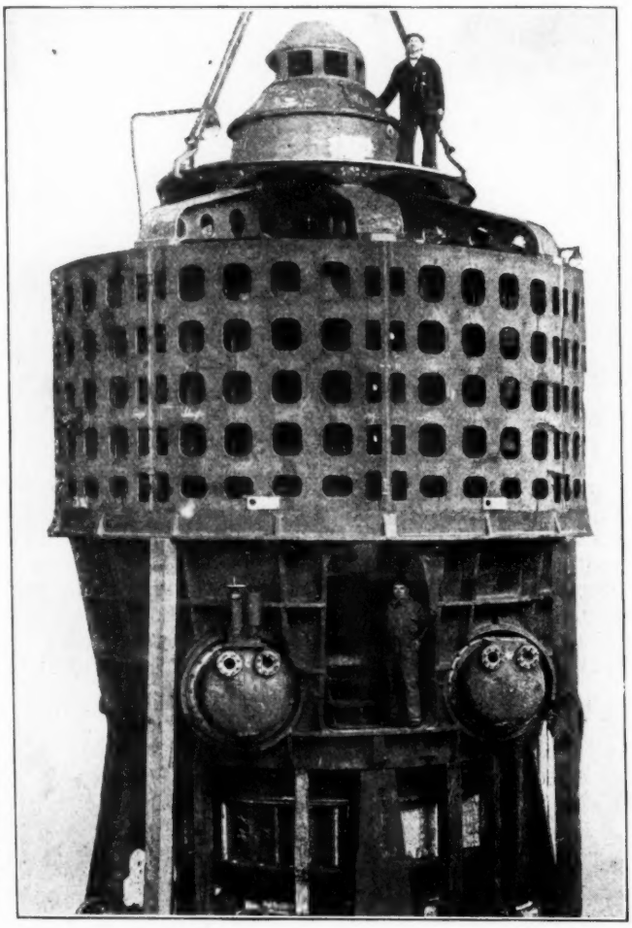


FIG. 5. ALLIS-CHALMERS 32,500-KV.-A. GENERATOR MOUNTED ON 37,500-HP. HYDRAULIC TURBINE

In its power plant at Springdale, Penn., the West Penn Power Company is installing four 1529-hp. boilers, each equipped with two thirteen-retort underfeed stokers, opposing each other and delivering the ash to a clinker grinder. An interesting feature is that the ashpit is sealed by carrying it down below the level of the water in the Allegheny River. It is intended to remove the ashes from the pits by bucket conveyors. This arrangement, in addition to sealing the ashpit, furnishes a novel means of quenching the ash.

At Cheswick, Penn., the Cheswick Power Company is building a power house, the boiler room of which will have twenty-eight boiler units of 2087 rated horsepower each, or a total of 58,436 rated horsepower. The first seven of these units are to be installed now, each equipped with a 17-retort, 21-tuyere underfeed stoker having a clinker grinder. This is the widest stoker the Westinghouse company has yet built. The boilers are 51 tubes wide and 18 tubes high. By the company's engineers it was found to be more desirable to use the wide boiler with single-end stoker equipment than the narrower boiler with a double fire.

It will be interesting to watch these two plants when they are both in operation, as they will use practically the same coal, carry similar loads and have the same make of stoker and boiler. The only difference will be that it is planned to operate the West Penn boilers at ratings of 250 per cent. up, while 175 per cent. will be the normal rate of operation in the Cheswick plant.

A relatively small but interesting plant is that of the American Smelting and Refining Company at Omaha. For simplicity, low initial cost, accessibility and minimum labor requirements, it is a model. At present it contains only one unit of two 406-horsepower boilers set over one eleven-retort underfeed stoker. Iowa coal containing on the average 14 per cent. moisture, 31 per cent. volatile matter, 35 per cent. fixed carbon and 20 per cent. ash, with a heat value of nine thousand British thermal units and a sulphur content of about six per cent., is burned at very high efficiency and with a minimum of operating troubles.

To utilize to the full the radiant energy from the fire, the boiler is made wider than usual and less tubes high. It is horizontally baffled at the fifth row of tubes. Because of its location back of the bridgewall, the superheater also draws on the radiant energy of the fuel bed and the burning gases in the furnace. No hot gases pass through the elements, still nearly uniform heat under all conditions of load is maintained.

The reinforced-concrete boiler house at Moline has been mentioned previously, and in the review of 1918 reference was made to the new plant at Kansas City. Since the war progress on this station has been more rapid, two twenty-five-thousand-kilowatt units now being completed and in operation. The probable ultimate capacity of the station will be two hundred thousand kilowatts. It is a typical Sargent & Lundy river plant resembling those at Cincinnati and Windsor. The boilers are of the cross-drum type having 13,512 square feet of steam-making surface. The operating pressure is 300 pounds and the superheat 250 degrees, giving a steam temperature of about 670 degrees, as compared to 650 degrees for the Joliet plant and 685 degrees for the Buffalo General Electric station. These final temperatures are near the safe limit of the steel now used in boiler manufacture. They are attained by the use of superheat ranging from 225 to 275 degrees. To reach approximately these same temperatures, the present in-

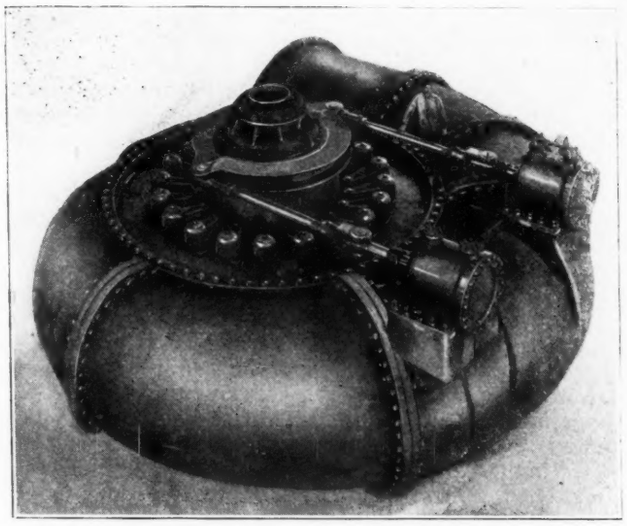


FIG. 6. I. P. MORRIS 37,500-HP. HYDRAULIC TURBINE

clination tends toward higher pressures and less superheat. As far as temperatures go, a pressure of six hundred pounds and superheat of one hundred and fifty degrees would not exceed the limits given in the cases cited.

The chain-grate stokers employed are unusually large, being 10 feet wide by 17.5 feet long. Large area and high stoker speed with relatively thin fires give the coal-burning capacity needed to operate the boilers at high rating.

For a high-pressure installation the economizer problem has been solved in an interesting manner. While cast-iron economizers have given safe and efficient service at pressures in the vicinity of two hundred pounds, conservative engineering opinion rather hesitates to subject the uncertainties of cast iron to pressures fifty per cent. greater. For economizers, steel is not so durable as cast iron on account of the greater corrosion, but it is safer. As a compromise, in the plant under discussion the economizer was made in two sections. A high-pressure element made of steel and resembling a section of a Stirling boiler, is placed above the boiler uptake and low-pressure cast-iron elements in the usual position above the boiler next to the induced-draft fan discharging to the smoke flue. As far as the water connections are concerned, the two sections are distinct. The feed water is pumped through the low-pressure section into a tank which supplies the suction of the feed pumps delivering through the high-pressure economizer to the boiler. In the low-pressure economizer the feed water is heated to a temperature somewhat less than two hundred degrees Fahrenheit to prevent the formation of steam and the resulting pressure, but still allowing it to pass to the high-pressure section at a temperature sufficiently high to prevent condensation on the tubes. The corrosion resulting from condensation is thus limited to the low-pressure elements, where it is better resisted by the cast iron and where leakage and deterioration are more easily controlled.

At Toledo the finishing touches are being given to the second large unit at the plant of the Acme Power Co. and at the Riverside station in Minneapolis the 25,000-kilowatt addition in one turbine unit is in operation. An interesting plant has been built by Armour & Company at South St. Paul. It consists of a refrigerating plant containing both compression and absorption systems and a mixed-pressure bleeder-turbine generating installation. The interesting feature is the balancing of the supply of exhaust steam with the requirements for process work in the packing plant. After careful selection of equipment in the first place, the final adjustment was left to the bleeder turbines, which make up a deficiency in the main exhaust or utilize an excess.

Mention of notable plants would not be complete without reference to the great expansion of power generation and distribution. Generating stations, hydraulic and steam, and even whole systems are being tied together, and water power, even of small capacity, is being utilized to the fullest extent, where before it was given only minor consideration.

FIG. 7. FIELD COIL 32,500 KV.-A. ALTERNATOR

To guide this movement and furnish to expanding industry and transportation an adequate, dependable and economical power supply, Secretary of the Interior Lane asked of Congress two appropriations, one of fifty thousand dollars to continue the power survey of the whole United States undertaken originally by the Geological Survey at the request of the Fuel Administration, and one of two hundred thousand dollars for a more intensive survey of the Atlantic coast section from Boston to Washington or Richmond, in which one-fourth of the entire generating capacity of the country is concentrated. The plan, which had the unqualified support of the engineering profession, was to enlist the coöperation of the electric industry in a careful economic and engineering investigation of the future power requirements of this region and of the best means of supplying its needs, taking into account the most efficient use of natural resources and linking all together in one great super-power system. With cheaper power and more general use of it, manufacturers could successfully compete in the world's markets and still main-

FIG. 8. RUNNER FOR 37,500-HP. TURBINE, FIG. 6

tain American standards of wages and living. Unfortunately, the proposal of Secretary Lane suffered the fate of the water-power bill and other well-merited legislation. The subject is too important to be set aside and should be given immediate consideration as soon as Con-

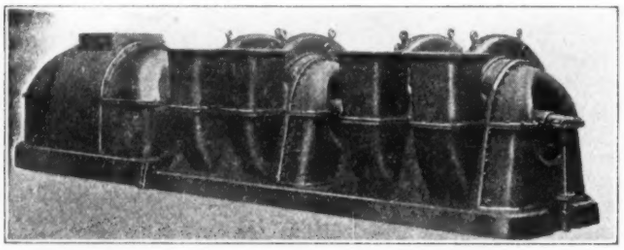


FIG. 9. RATEAU BATTU SMOOT 1700-HP. 3600-R.P.M. SYNCHRONOUS MOTOR-DRIVEN BLOWER

gress has disposed of its foreign-relations problems and the return of the railways.

Steam Turbines and Auxiliaries

A notable incident was the starting up of the great three-element cross-compound turbine unit of the Interborough Rapid Transit Company of New York. With a two-hour rating of 70,000 kilowatts and a normal output of 60,000 kilowatts, it is the most powerful prime mover in the world. In the turbine field much of the time seems to have been spent in digesting operating data obtained from the numerous large units recently installed, in determining and correcting the cause of accidents to a number of large machines, all of the same type, and in studying limitations as to speed and capacity of single-shaft units. The Committee on Prime Movers of the National Electric Light Association were of the opinion that with present constructional problems of prevailing frequencies and speeds and the recognized factors of safety, efficiency and cost, the size of the systems today will hardly warrant single units larger than 30,000 kilowatts capacity. In particular cases, and until increased reliability, as well as improvements in operating efficiencies, have been established, even extended systems will not justify the use of larger units. While on the whole this statement found support, there is general confidence that larger turbines having a greater proportionate size to the total

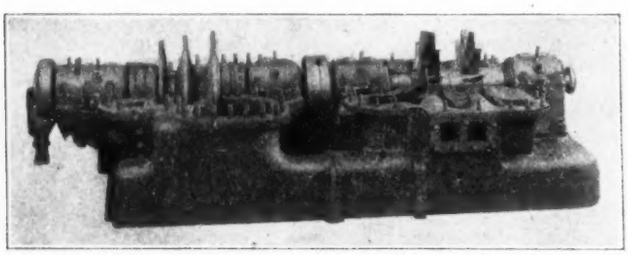


FIG. 10. RATEAU BATTU SMOOT 1000-HP. 8750-R.P.M. TURBO-BLOWER UNIT

station capacity will be developed gradually. Equally high efficiency could perhaps be secured in small machines, but the initial cost per kilowatt would be greater.

Later, the same question was discussed before the American Institute of Electrical Engineers. Turbine designers agreed that the limit of a single-shaft machine did not lie in the generator, but in the turbine—and in the last wheel of that. Concerning this limitation there were two sets of adherents, one favoring the division of the turbine into separate compounded elements, each driving its own generator and each capable of operating alone under high-pressure steam. Engineers of the opposing school preferred dividing the installation into a number of identical units of smaller capacity rather than into a number of dissimilar elements forming the successive stages of a compound unit. The accidents that had occurred to large single-shaft turbines were due to fluttering and vibration of the wheels, which had been made too thin in order to save weight and space. Stiffening the wheels and putting the openings in them nearer to the hub, where a suitable reinforcement could be provided, had overcome the trouble.

Electrical engineers were positive that generators could be designed conservatively and constructed for units of fifty thousand or even one hundred thousand kilowatts, but the higher the capacity the higher the voltage must necessarily become. For speeds of twelve hundred revolutions per minute and lower, the stator, and for higher speeds, the rotor, is the limiting member.

Relative to steam condensers, there is little to say, except that in size and refinements they have kept pace with the large turbine units. Notable among these is the surface condenser Fig. 3, which has fifty-six thousand square feet of active tube surface, and the jet condenser Fig. 1. The latter is capable of passing thirteen million gallons of water per hour. Certain large condensers have been placed on spring supports without expansion joints. Another method is to hang the condenser from the turbine foundation, which accomplishes practically the same results as the springs. Mention might be made of the prominent place in marine work given the steam air ejector and its increasing use in the stationary power plant. An over-all efficiency higher than that of the hydraulic air pump is claimed for this device. The disadvantage of a greater steam consumption is more than offset by the recovery of practically all the heat that it uses.

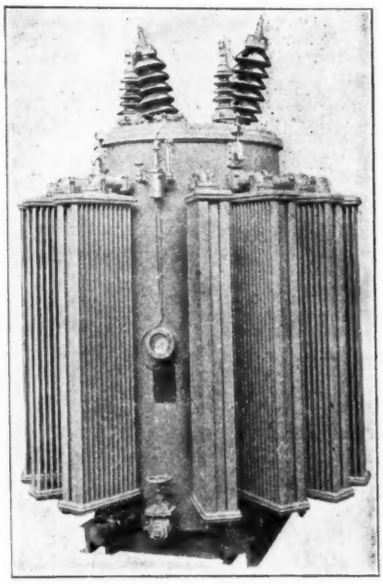


FIG. 11. WESTINGHOUSE 8333-KV.-A. SELF-COOLED TRANSFORMER

A new development is a four-compartment surface condenser in which tubes may be cleaned or repairs made while the turbine is in service. Each compartment is equipped with a set of valves to control the circulating water. Shutting off the valves allows a compartment to be cleaned. It is then placed in service and the same operation is repeated on the remaining sections in turn.

Rotary Blowers and Compressors

Although differing entirely from the steam turbine in design and use, but still a rotary machine, mention might be made here of a large synchronous motor-driven turbo-blower, Fig. 9, installed for the Tennessee Copper Company to discharge air into the main air line which directs the blast into several copper smelters.

Normally, 125,000 cubic feet of air per minute is discharged at a pressure of 50 ounces, this output probably being the largest ever delivered by a single unit. The blower Fig. 10 is driven by a one-thousand-horsepower steam turbine, runs at 8750 r.p.m. and compresses 15,000 cubic feet of free air per minute to a pressure of fifteen pounds. The dimensions of this unit are remarkably small for the capacity, the outside diameter of the blower casing being approximately thirty-six inches.

Word came recently of a high-pressure rotary compressor of the eccentric rotor, telescopic blade type, per-

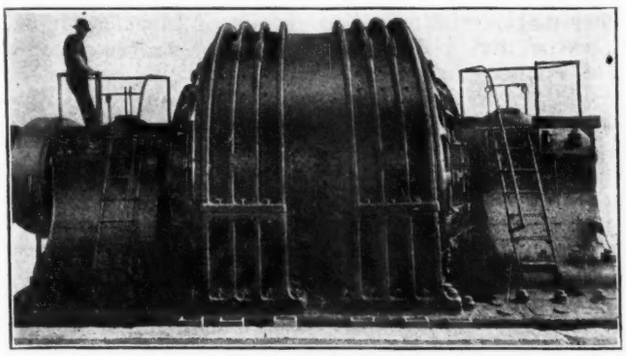


FIG. 12. GENERAL ELECTRIC 5000-HP. DOUBLE-UNIT DIRECT-CURRENT MOTOR

fected by W. G. E. Roloff, of Belleville, Illinois. According to report the leakage, friction and packing troubles inherent with this type have been eliminated to such an extent that a volumetric efficiency of 92 per cent. when compressing to one hundred pounds pressure is commercially obtainable. Other claims are that this machine without alteration will handle gas, air or liquid, or a gas and a liquid at the same time, and that it is possible to obtain a pressure of five hundred pounds in a single-stage machine and one thousand pounds in three stages with the elements on the same shaft—all this with a machine of about one-tenth the weight and occupying about one-twentieth the floor space required by a reciprocating compressor of the same capacity.

Steam Engines

A canvass among builders of reciprocating steam engines revealed that during the first half of this year, when rising costs of material and labor and the uncertainty as to whether these would soon reduce led to hesitation in new construction, there was not the usual demand for steam engines. But more recent conditions have indicated that the steam engine is by no means a back number, and the demand is active, especially in the small and medium sizes. In the large sizes, of course, there is still a large demand for water-works pumping.

The rising fuel and labor costs have created a market for the more economical types of engine, and have also resulted in a great impetus to the uniflow type. There are now nearly a dozen firms building these engines, many of whom have taken out licenses during the past year. This type, because of its flat load curve, makes an appeal where variable load conditions are encountered.

A giant Nordberg hoisting engine, even larger than the famous Tamarack hoist in the Calumet district, which had previously held the record, is being installed at the No. 2 shaft of the Quincy Mining Co. In general arrangement it is similar to the Tamarack hoist, the cylinders and frames being set at an angle of 45 deg., with the main bearing and drum shaft forming the apex of the triangle. The two high-pressure cylinders work on a common crankpin at one end of the crankshaft and the two low-pressure cylinders work on a common crankpin on the opposite end of the crankshaft. The high-pressure cylinders are 32 in. in diameter, the low-pressure cylinders 60 in. in diameter and all four cylinders have a common stroke of 6 6in. The hoisting drum is 30 ft. in diameter and approximately 30 ft. face. It is cylindro-conical in shape, having cones at each end and a center cylindrical section. The drum is built with a winding capacity of 13,000 ft. of 1⅝-in. rope in one layer. The inclination of the shaft is about 40 degrees.

The hoist will lift 20,000 lb. of copper ore per trip in skips weighing approximately 10,000 lb. each. The total rope pull is 52,000 lb., as compared to 42,000 lb. for the Tamarack hoist, and the torque when operating in balance is 275,000 ft.-lb. The hoisting speed will be 3200 ft. per min. The engine is equipped with a counter-current jet condenser and will be supplied with steam at 160 lb. boiler pressure. The auxiliaries, such as brakes, reversing gear and throttle, are operated by oil under pressure supplied from an accumulator.

Oil Engines

The past year has seen few radical changes in oil-engine design. The market for these engines is promising, and it is anticipated that the greater use of fuel oil for boiler purposes will carry with it a demand for oil engines in localities in which they have heretofore been used very little. This will be due to the modification of city ordinances regarding fuel-oil storage and to the fact that the oil companies will push the oil business in these localities to a greater extent.

Both the two- and the four-stroke cycle types are being built, although the latter is in the majority. Cer-

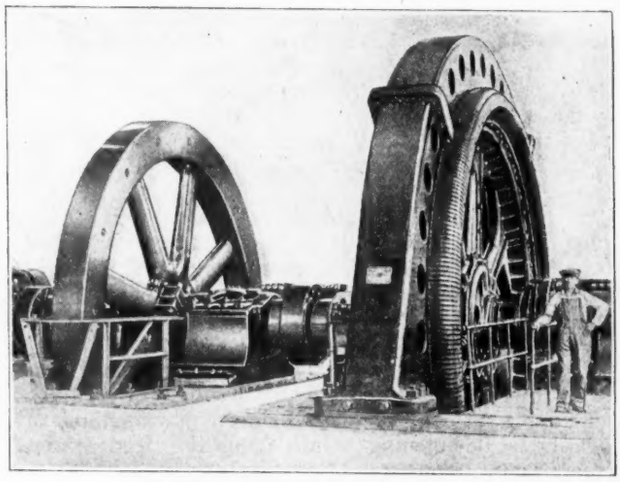


FIG. 13. GENERAL ELECTRIC 4000-HP. 6600-VOLT INDUCTION MOTOR

tain companies, by careful attention to design and workmanship, appear to have successfully overcome some of the previous troubles attributed to the two-stroke-cycle type.

The marine field is promising, and a considerable number of Diesel engines have been built and more are on order for cargo carriers. Twin engines of moderate power are apparently the more popular.

A considerable number of stationary units are being built for mining and oil-line pumping service, as well as scattered industrial applications. Those in the mining

districts are mostly of the larger size, vertical type, and go to the Southwest. A number of these engines of the two-stroke-cycle type, in sizes up to twelve hundred and fifty horsepower, five cylinders, have been installed, and others are building in sizes up to twenty-five hundred horsepower, five cylinders. The largest four-stroke-cycle engine built for stationary practice in this country is sixteen hundred horsepower.

Fig. 14 shows a 1250-b.hp. two-stroke-cycle Diesel engine built by the Nordberg Manufacturing Company for driving a 6500 cubic foot variable-speed compressor at an elevation of 5000 feet. The engine has five working cylinders, each 20¾ by 26 inches, delivering 250 horsepower, and the sixth cylinder is the scavenging pump. The speed will vary from 180 to 80 r.p.m. The weight of the engine is 380,000 pounds, or slightly over 300 pounds per horsepower. A fuel consumption of one pound of oil per 1000 cubic feet of air compressed to 90 pounds is anticipated.

Boiler-Room Tendencies

Relative to the boiler room, previous reference has been made to the possibilities of higher pressures and to the more common use of instruments and labor-saving devices. In large plants the tendency seems to be toward boilers of moderate size rather than enormous capacities in one unit, the range running from one thousand to fifteen hundred horsepower. Boiler-setting design and materials used have received much attention of late. An innovation is the use of reinforced-concrete settings by the engineers of the Robert Gair Company, of Brooklyn. In the older boiler room of the company containing hand-fired return-tubular boilers, reinforced concrete was used for the settings, and cinder concrete containing no sand formed the lining for the furnaces. Eight years' use confirmed the reliability of these settings, so that recently, when adding additional boiler capacity, engineers of the Gair company had no hesitancy in prescribing concrete for the new settings and reinforced-concrete columns exposed to the heat of the furnace for support of the boilers, the latter being large stoker-fired return-tubular boilers. Results from the latest installations will be watched with interest, for if concrete can be made safe for boiler settings, it will lower the construction cost appreciably and no doubt come into wide use for the purpose.

Recent tendencies, particularly with high boiler ratings, is to build the walls of the furnace with as few different kinds of materials as possible and to make them solid, well-bonded and homogeneous. This development has been carried to the extent of building furnace walls of solid firebrick.

During the year a new marine boiler of the Heine cross-drum type was reported and publicity was given to a "double-service" boiler offering a new method of separating scale-forming solids from the feed water. The apparatus consists of a live-steam feed-water purifier located within a horizontal fire-tube boiler which may be of the locomotive, Scotch or return-tubular type. Carbonates, sulphates, magnesia, mud and oil are retained in the purifier and do not get into the boiler. As the fire strikes no portion of the purifier, the deposits do not bake on as they would in the boiler, and remaining in the form of a sludge, can be blown out through the blowoff at any time the boiler is under pressure.

Boiler explosions were about as numerous as usual, our old "enemy" the lap-seam boiler "hogging" the bulk of the accidents. The most disastrous accident of the year was the explosion occurring at Mobile, which resulted in four deaths and a property damage exceeding one hundred thousand dollars. Two water-tube boilers, one a two-hundred-horsepower Stirling and the other a Heine of nearly the same size, let go almost simultaneously.

Chain Grate and Underfeed Stokers

In the stoker field there has been great activity. Manufacturers of all types, and there are many new faces among them, have been busy trying to catch up with the demand. Orders held in abeyance during the war and the present labor situation within the power plant are the reasons. To meet the desire for an automatic stoker that can be forced to a point of capacity far in excess of the limits of natural draft, various chain-grate manufacturers have been attempting to apply forced draft to their stokers, with provisions to readily convert them to the natural-draft type during low-load periods. The stokers have been divided into distinctive compartments so that air pressure and volume may be suited to the requirements of the fuel passing over each compartment. The air is supplied by one large fan, with damper regulation at each compartment, or, as in one case, by a small turbo-blower for each compartment. Chain-grate stokers with forced draft have been operating satisfactorily for some time with various kinds of fine fuel such as anthracite screenings, culm, coke breeze, etc., and more recently successful installations have been made for low-grade fuels, such as bituminous coals high in ash, and lignites with excessive moisture.

Combustion rates up to seventy pounds of Illinois bituminous coal per square foot of grate area per hour have been maintained, and with the performance of the steam locomotive in view there are hopes of exceeding by a wide margin the figure given. The thickness of the fuel bed needed to prevent the air from blowing holes in the fire, the added clinker troubles with thick fires, the regulation of the various compartments, and furnace upkeep are factors holding back the advance. With a positive pressure in the furnace preventing infiltration of cooling air through the walls, deterioration of brickwork and refractory material is rapid.

For these very reasons a prominent manufacturer of chain grates is attacking the same problem from a different angle. Believing that it is final over-all results that count and seeing no advantage in a gain overcome by upkeep, the extra coal for high ratings is burned with natural draft by increasing the grate area and speeding up the stoker to the limit. Speeds of seven inches per minute, as compared to old standards of one to three inches per minute, have been attained. Thin fires are the rule, the fuel bed, depending on the character of the coal, being just thick enough for the coal to burn out completely during the active travel of the grate. With these thin fires there is no disturbance of the fuel bed and consequently no clinkers. The fire is bright and quick, and with a steady load and uniform coal, conditions are ideal. Fisk Street Station of the Commonwealth Edison Company and the new Kansas City plant furnish examples of the large stokers the above practice requires. In either station chain grates having the unusual length of 17.5 feet have been installed. Owing to the use of economizers, however, induced draft is employed.

In underfeed stokers the most important developments are the perfection of power dump grates and the clinker grinder, both of which are coming into more general use, the choice depending upon the character of the coal burned. Another praiseworthy improvement is the provision of sectional drive, wherein the total number of retorts is divided into sections of a few or several retorts, depending upon the size of the stoker.

Each section may be operated without interference with other sections, giving a flexibility highly desirable in maintaining a uniform fuel bed on the wide stokers now in use. Various methods of drive have been developed, and the acceleration or retardation of the feed of the coal is facilitated by means of two-speed power boxes. In stokers of extreme width this sectionalizing in a moderate degree has been carried to the chain grate.

Smoke Abatement

Combustion is a subject naturally suggested by stokers, and for the good of humanity as well as the pockets of plant owners, it is desirable that it be of the smokeless variety. Since the war period of dirty coal and fuel unfamiliar to the plant, there has been some recovery from the condition of smudge and smoke that was generally prevalent. Judging from records of the past, Chicago has taken a backward step in destroying the identity of its smoke department and making it an adjunct of the board of health. The old policy of education and coöperation that had proved so successful has been supplanted by arbitrary ruling based from the health standpoint. The violator is no longer shown how to mend his ways. Good combustion, which would solve the problem from all angles, is not considered.

A ray of hope comes from Salt Lake City, where the Bureau of Mines, operating under the provisions of the Sundry Appropriations Bill, in coöperation with the University of Utah, is making a thorough investigation of the smoke conditions. The most approved engineering methods are being used in securing data from which a working plan to reduce the smoke nuisance will be evolved. Authority is given the bureau to extend aid to other cities interested in smoke abatement.

All over the world there has been rapid expansion of the application of hydro-electric power. The shortage of coal during the war gave impetus to the movement, and today there is scarcely a country having hydraulic resources that is not considering the better use of its dormant water power or is already carrying out well-defined plans.

Norway has made exceptional progress in this line, and Canada is a close second with its 276 hydraulic horsepower per thousand of population, as compared to one hundred horsepower for the United States. In the former country the great Queenstown development of 300,000 horsepower on the Canadian side of Niagara is now under construction and orders have been placed by the Hydraulic Power Commission of Ontario for the first three units. Under a head of 320 feet each turbine will develop 52,500 horsepower at the point of maximum efficiency, and about 60,000 horsepower at full gate opening.

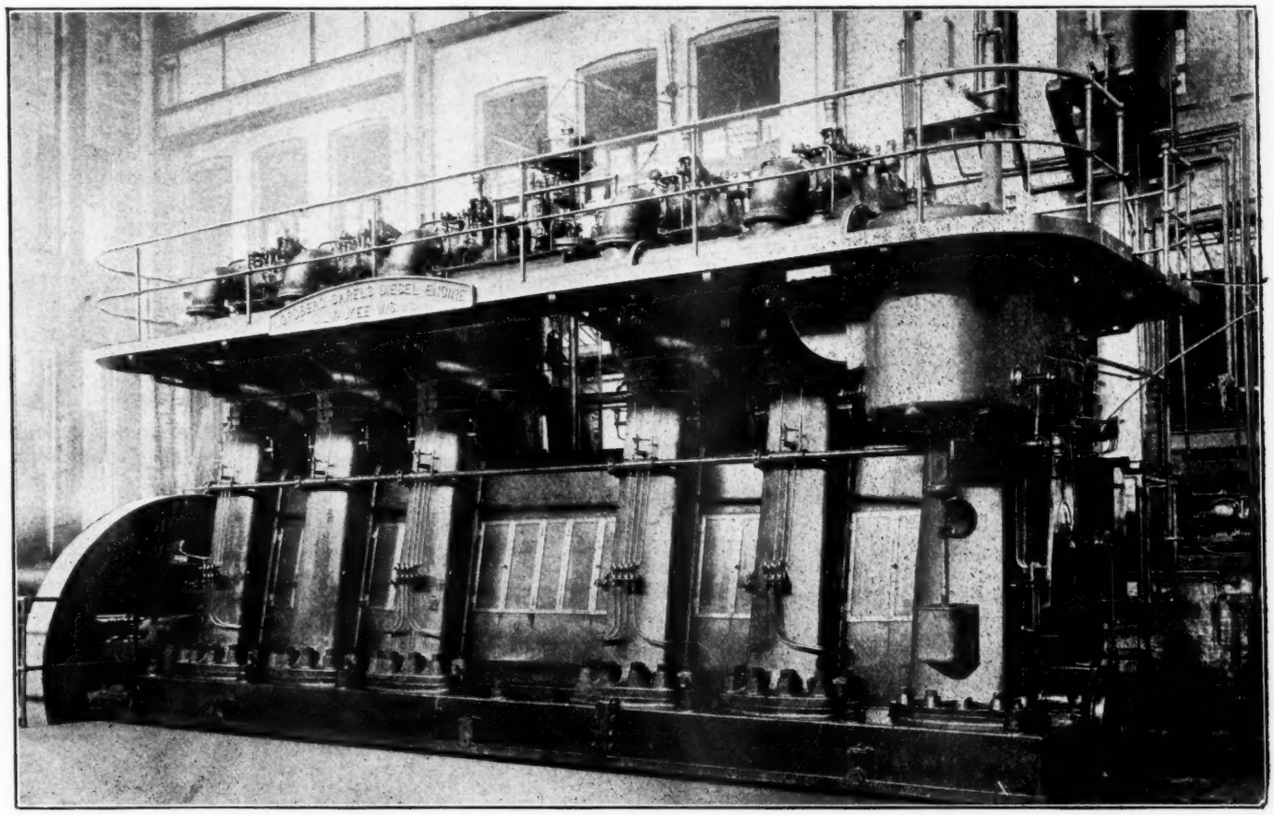


FIG. 14. TWO-STROKE CYCLE, 1250-HP. DIESEL DRIVING AIR COMPRESSOR

On the American side the Niagara Falls Power Co. is installing three units, each to develop 37,500 horsepower under a 214-foot head. The type of hydraulic turbine used to drive two of the generators is shown in Figs. 6 and 8. The first unit is nearly ready for operation and for the time being ranks as the most powerful turbine in the world. These machines are in line with the modern tendency of installing high-powered units, although Dr. C. P. Steinmetz has expressed the opinion that the country is approaching the limit of water-power development by present methods of concentrating in large stations.

Other tendencies in the field are the development of small water-power plants connected together and under remote control from the master station, the provision of piezometer equipment in each turbine intake so that

operating efficiency may be checked and maintained, and general attention to details of design affecting the ease of operation and economy.

One of the latest developments is a new governor designed by M. Seewer, a Swiss engineer, for high-head hydraulic turbines of the Pelton type. The governing is effected by changing the shape of the jet by guide members located in the interior of the jet nozzle and so arranged that the jet may be practically cylindrical or may be partly or totally dispersed. A slight dispersion of the jet produces a material reduction in the hydraulic efficiency of the turbine and at complete dispersion no useful power is produced.

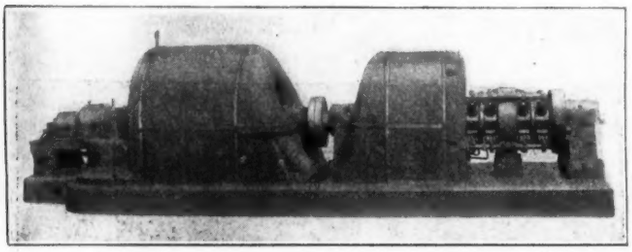


FIG. 15. RATEAU BATTU SMOOT 1000-KW. 2700-R.P.M. DIRECT-CURRENT TURBO GENERATOR

The Electrical Field

Although new types of electrical apparatus have been brought out during the past year, the greatest development has been along the line of large-scale operation with standard equipment. The year has seen the placing in operation of the largest turbo-generating unit ever built; the delivery of equipment for the world's largest furnace installation; the construction of the largest electric locomotives; the completion of the design for a transformer of higher rating than has yet been manufactured; and the construction of three of the largest hydro-electric generating units built up to the present time, although orders have been placed for machines exceeding these in size by about thirty per cent.; the export shipment of the electrical apparatus for what will be the first electrically driven steel blooming mill to be erected in the Far East; and the export shipment of the equipment for a large hydro-electric development in Europe.

The 60,000-kilowatt 25-cycle three-element cross-compound unit, Fig. 2, was placed in service at the Seventy-fourth Street Station of the Interborough Rapid Transit Company, New York City, in the early part of the past year, and the performance of this unit indicates that the construction and operation of such a machine and even one of larger capacity is within the premise of good engineering. These generators are so connected to the busbars that any combination of them can be operated in parallel. In practice, however, all three machines are brought up to speed together, and synchronized through a single oil switch connecting the generators to the main busses. An indication of the confidence in such machines is shown in the construction of the new plant at Cheswick, Penn., of the Duquesne Light and Power Company. In this plant it is planned to eventually install a total of five of these machines. The first and probably two of the units will be put into service during the coming year. A similar sixty-cycle unit was installed in the United States Government Nitrate Plant No. 2 at Muscle Shoals, Alabama. In this case the generator driven by the high-pressure turbine is operated at 1800 r.p.m. and the two driven by the low-pressure turbines run at 1200 r.p.m.; the generators, however, are all of the same capacity. The 45,000-kilowatt unit, Fig. 4, installed in the Detroit Edison Company's plant has also been in service for the past year.

Three of the most notable hydro-electric generators, as to capacity, ever built have been completed during the year, and the installation of these machines is well under way at this date. One of these generators is being built by the Westinghouse Electric and Manufacturing Company, one by the General Electric Company and the third by the Allis-Chalmers Manufacturing Company. The last-named company has built the complete unit both generator and hydraulic turbine as shown in Fig. 5. An idea of the dimensions of the generating unit may be gained from Fig. 7, which shows one of the field coils used in the Westinghouse machine. Each machine is rated at 32,500 kilovolt-amperes and will operate at 150 r.p.m. and generate 12,000-volt three-phase twenty-five-cycle current. The general outline of all three generators is similar to the unit shown in Fig. 5. As previously stated, these machines are being installed in the Hydraulic Power Company's plant of the Niagara Falls Power Company at Niagara Falls, New York. Among other important hydro-electric developments are the Caribou development of the Great Western Power Company, which is installing equipment and transmission lines for operation at 165,000 volts. Two 22,222-kilovolt-ampere 11,000-volt 60-cycle units are included in the initial installation. Orders were placed during the year for three of the six generators that will be installed at the Queenstown development of the Hydro-electric Commission of Ontario. These generators are rated at 45,000-kilovolt-ampere normal, and 50,000-kilovolt-ampere maximum continuous rating. The speed of these machines will be 187 r.p.m. and will generate 12,000-volt current.

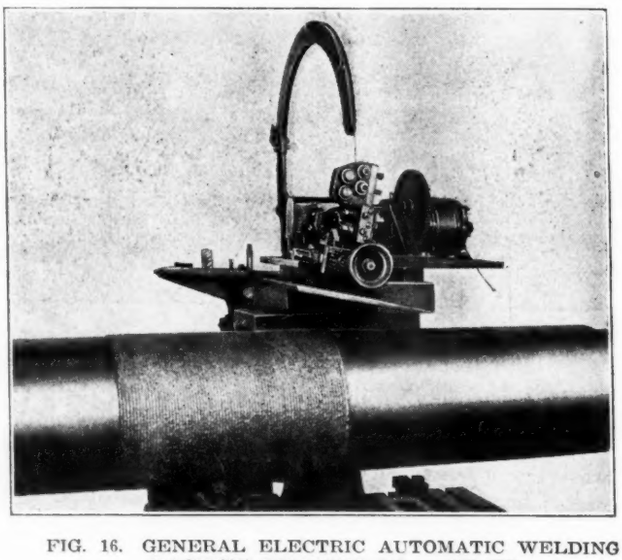


FIG. 16. GENERAL ELECTRIC AUTOMATIC WELDING MACHINE BUILDING UP A SHAFT

The majority of installations during the year have followed along well-established lines in both capacity and design features. However, the unit that is now being built for the Southern California Edison Company may be considered a departure from standard practice. This unit is a 15,000-kilovolt-ampere 600-r.p.m. 50- to 60-cycle frequency changer set. Not only is this the largest in capacity thus far to be built, but its voltage is the highest that a revolving machine has been built for, motor and generator being designed for

15,000 and 18,000-volt normal operation respectively. An order has recently been placed by the Consumers Power Company, Jackson, Mich., for a 10,000-kw. frequency-changer set. This set is to operate so as to exchange power in either direction between a thirty-cycle and a sixty-cycle system.

Among the transformers constructed during the year are to be found a number of 8333-kilovolt-ampere 66,000-volt self-cooled type, one of which is shown in Fig. 11. These are the largest self-cooled units that have been built. The design has also been completed for a 23,600-kilovolt-ampere water-cooled transformer

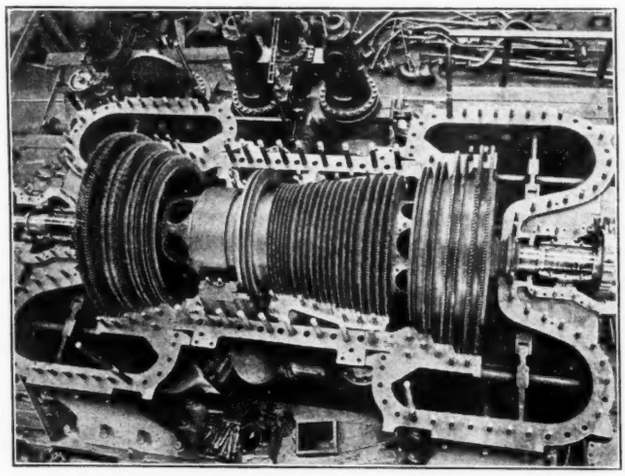


FIG. 17. INTERIOR OF WESTINGHOUSE TURBINE INSTALLED AT OSAKA, JAPAN

for 132,000-volt operation. This is the highest rated transformer yet attempted, and in physical size it will be considerably larger than its nearest rival. The building of eleven 11,500-kilovolt-ampere water-cooled transformers for 150,000-volt service is nearing completion. These transformers are designed for 72,000 volts on the low-tension side and for delta connection on the high-tension side.

A forty-inch reversing blooming mill at the Sparrows Point plant of the Bethlehem Steel Company was put in operation early in the year and has since been in successful operation. This equipment has a double-unit reversing motor, Fig. 12, with a normal continuous capacity of 5000 hp, at 50 r.p.m. and a momentary torque capacity of approximately 2,000,000 lb. at one-foot radius at any speed from zero to 50 r.p.m. During the early part of the year a 36-inch by 110-inch plate mill was started at the Fairfield Works of the Tennessee Coal, Iron and Railway Company. This mill is driven by a 4000-hp. 82-r.p.m. 6600-volt induction motor, Fig. 13. A forty-five-inch blooming mill for this installation is driven by a double-unit reversing motor with a normal continuous capacity of 5600-hp. at 55 r.p.m., having a momentary torque capacity of 2,300,000 pounds.

Considerable attention has been given to the possibility of using 220,000 volts for high-tension transmission of electrical power during the past year. The development of a 1100-mile 220,000-volt transmission line to be put in operation on the Pacific Coast, has been suggested, this system to have a capacity of 1,500,000 kilowatts eventually.

The tendency in the use of synchronous machines for power-factor correction and voltage regulation on high-voltage transmission systems is indicated in the 30,000-kilovolt-ampere synchronous condenser being built for the Southern California Edison Company. In the design of high-speed turbine-driven direct-current generators, the one shown in Fig. 15 is representative. This generator is of 1000-kilowatt capacity, operates at 2700 r.p.m. and generates 250-volt current. One of its radical features is the commutator, which of necessity must be of considerable length to provide the required brush contact surface to handle the 4000-ampere normal full-load current.

One of the most notable electrically driven mine-hoist equipments constructed during the year was that built for the Chicago, Burlington & Quincy Railroad Company and placed in operation at this company's coal mines operated by the Valier Coal Company. The hoist motor is 1350 horsepower direct-connected to a single-cylinder drum on which two ropes wind for balance operation with two dumping skips. The rope speed of this installation is 1500 feet per minute. A noteworthy feature of this installation is the semi-automatic operation, as the trip may be started either by an operator on the hoist platform in the usual manner or by the skip tender at the bottom of the shaft, and is automatically retarded and brought to rest, stopping accurately in the dump and at the loading chute.

Electric-arc welding during the year has been characterized by considerable effort to improve the art. The American Welding Society was formed and may be considered the successor to the Welding Committee of the United Emergency Fleet Corporation and the National Welding Council. It is to be hoped that the formation of this society will bring about the degree of coöperation between the various welding interests that is so

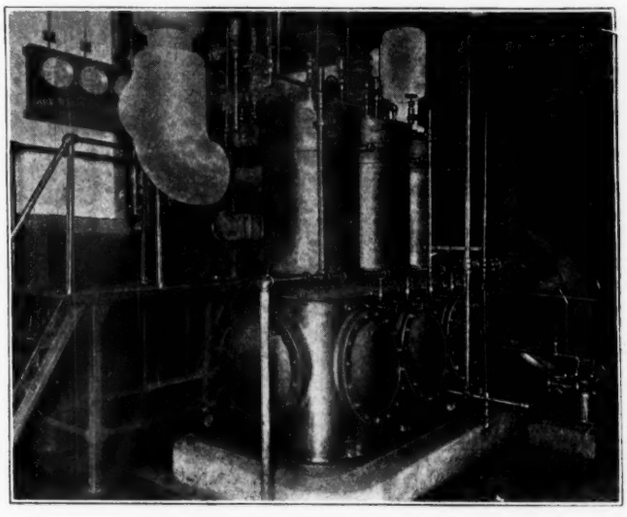


FIG. 18. ONE OF THE YORK VERTICAL COMPOUND COMPRESSORS, MERCHANTS REFRIGERATING CO., NEW YORK

necessary for the advancement of the art. The operator is still being considered one of the most important factors in the making of reliable welds, and it is being appreciated to a degree that some of the manufacturers of welding equipment have established schools for training operators sent by purchasers of their equipment. One of the most recent designs in electric welding with metal electrodes is that of an automatic machine shown in Fig. 16. Here the machine is shown building up a shaft that has been incorrectly machined.

Export of Electrical Machinery

Among the notable export shipments of electrical equipment during the year are: The equipment for the

first electrically driven steel blooming mill to be erected in the Far East. This equipment is to replace a steam engine now operating a forty-inch reversing mill. The mill will form part of the plant of the Imperial Steel Works of Japan near Tokio, and will be operated by a 3500-horsepower single-unit motor, of the reversing blooming-mill type, taking direct current at six hundred volts. Two 25,000-kilowatt steam-turbine driven units, which, when installed, will complete the largest steam-driven electrical installation in the Far East, are now being erected at Osaka, Japan, for the Osaka Electric Light Company. The interior of one of these turbines is shown in Fig. 17. When these two units are installed, they will bring the capacity of this plant up to 75,000 kilowatts. Electrical equipment for twenty electric furnaces has been shipped to the Glomfjord Smeltverk Company, of Glomfjord, Norway. A 1300-kilovolt-ampere single-phase transformer is required to supply power to each of the equipments. Another notable shipment was the two 14,060-kilovolt-ampere 6600-volt hydro-electric units built for the Ebro Irrigation Company in Spain. An order has been placed in this country for the electrical equipment for a forty-inch reversing blooming mill, for the Tata Iron and Steel Company, India. This equipment is similar to the forty-five-inch blooming mill at the Fairfield Works of the Tennessee Coal and Iron Company, previously referred to.

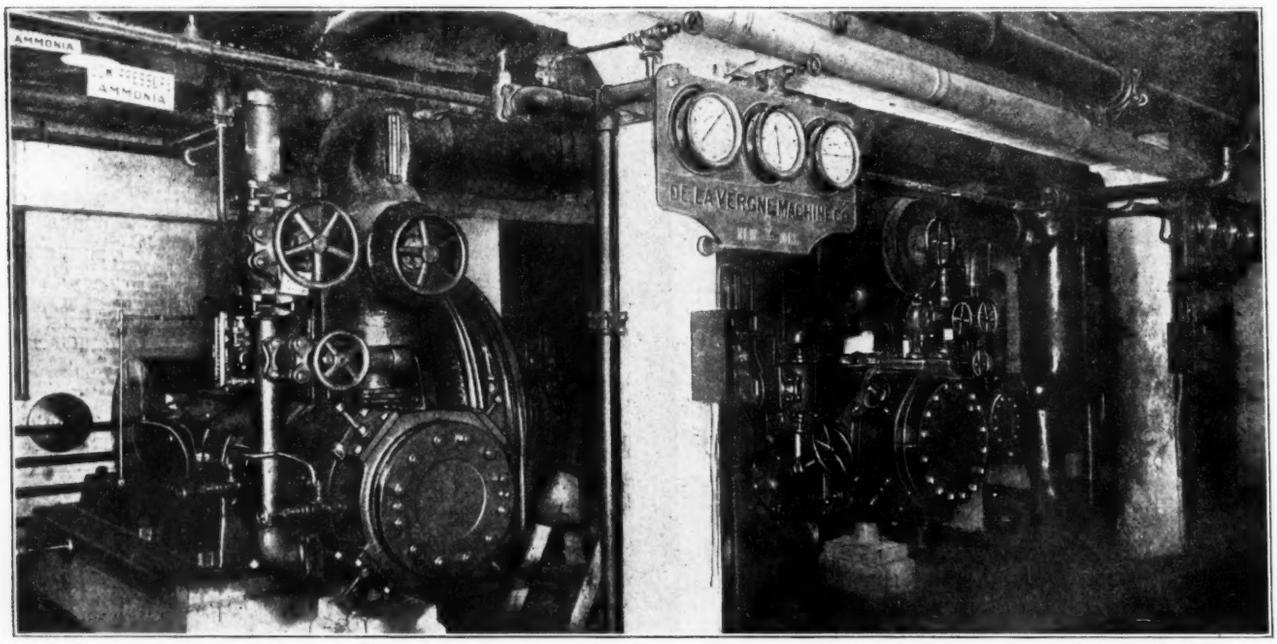


FIG. 19. THE DE LA VERGNE HIGH-SPEED HORIZONTAL COMPRESSORS, MERCHANTS REFRIGERATING CO., NEW YORK

Advance in Refrigeration

Refrigeration has witnessed a wider application and more scientific development of the high-speed compressor driven by the synchronous motor. Engineers and executives are anxiously awaiting reliable performance data of the high-speed plants which also embody refinements in design to improve heat transfer in condensers and coolers.

Two of the largest synchronous-motor-driven compound, compression refrigerating plants in the United States have been installed recently by the Merchants Refrigerating Company, of New York. The capacity of either plant is 550 tons of refrigeration. In one case three-cylinder compound vertical compressors are employed and in the other, machines of the horizontal double-acting type using feather valves. The speed exceeds 200 r.p.m.

Ammonia intercoolers are used between the low-pressure and high-pressure compressors in both installations. In one plant they are of the usual accumulator design, consisting of large cylindrical tanks with helical liquid cooling coils. In the intercoolers of the other plant the hot discharge vapors from the low-pressure compressor are cooled by means of a liquid rain over baffle plates.

The brine coolers are of the horizontal-shell straight-tube type in one plant and of the standard shell and helical coil design in the other. One of the horizontal coolers is supplied with helically wound iron strips in the tubes to maintain a nearly uniform brine temperature at any one point. Although this cooler has the same effective brine-cooling surface as the others, it has shown under the same conditions of operation, fifty per cent. greater capacity.

Ammonia-condensing units in one of these plants are of the shell and straight-tube type erected vertically. The water-distributing device is so constructed that an annular ring of water inside of the tube flows down by gravity to the collecting point underneath the condenser. On account of the excellent distribution of the water the liquefaction temperature is never over five degrees above the outlet-water temperature. The advantages of this type of condenser are the small space occupied, the high efficiency and the ease with which they can be kept clean.

One of the plants was laid out to use not in excess of 1.8 brake horsepower per ton of refrigeration at 3 lb. back pressure and 165 lb. condenser pressure. The other was designed to produce a ton of refrigeration on not to exceed 1.65 brake horsepower at 8 pounds back pressure and 165 pounds condenser pressure. Present indications are that as soon as all necessary adjustments have been made, the power consumption will be less than the figures given, for the conditions stipulated.

The new synchronous-motor-driven high-speed refrigerating plant of the Quincy Market Cold Storage and Warehouse Company, of Boston, has received such recent mention in these columns that it will be unnecessary to enumerate details.

Engineering Societies Active

Never in their history have engineering societies been so active as in the past year. From the consideration of purely technical subjects they are now assuming greater activity in the industrial field, are following more closely engineering legislation, and directing engineering matters of local or national import. In other words, the plan is to render the maximum of national, social and political service. To carry on this work most effectively there is full realization of the value of coöperation and unity of action. A joint conference committee of the five great associations of the country has already outlined a plan to form a single comprehensive organization for securing united action of the engineering and allied technical professions in matters of common interest. It is to be made up of a federation of local and national engineering societies with the existing specialized professional associations still retaining their identity. Local societies and sections of the existing professional associations would thus be joined together for concerted action in their respective territories and the general engineering society, made up of representatives from the local groups, would care for matters of national scope. Action on this plan awaits the approval of the societies represented in the conference.

Another movement on foot is the formation of an American Engineering Standards Association, the objects being to unify and simplify the methods of arriving at engineering standards, to secure coöperation between various organizations, to prevent overlapping or duplication of work and to coöperate with similar organizations in other countries to promote international standardization. Realizing the value of coöperation from war work along these lines, the five national associations previously referred to invited the Government Departments of War, Navy and Commerce to appoint representatives to act with them to continue this work. The engineering standards committee so formed has drawn up plans of action that should not interfere with organizations already doing excellent work in this line and is awaiting ratification by the governing boards of all the societies and departments represented.

In the refrigerating industry the foremost societies of the field have united to form a parent body known as the American Association of Ice and Refrigeration, the objects being to avoid duplication of effort and by joint activity to do more effective work on the problems of the field.

The National Safety Council has approved the organization of an engineering section, so that civil, mechanical, electrical, mining and chemical engineers may contribute more effectively toward the solution of purely engineering problems encountered in safety work.

In passing, mention should be made of the effort to raise and standardize salaries of engineers. In this movement the American Association of Engineers took an active part.

The establishment of a Bureau of Research by the American Society of Heating and Ventilating Engineers and the arrangement by which a portion of the magnificent new laboratories of the Bureau of Mines at Pittsburgh was placed at its disposal, with Professor John R. Allen as director, should prove of inestimable value to a field lacking in constants and reliable data on heat losses.

Other work in which the aid of the Bureau of Mines is sought is the perpetuation of power economy by continuing the work of the Fuel Administration. An effort in this direction is being made by the International Power Economy Conference, but before the Bureau can assume this new rôle, funds are needed, and it is the primary intention to create sufficient public sentiment to influence favorable action by Congress.

Passage of the Jones-Reavis bill is another duty to be imposed on Congress as soon as the "back-home" campaign has had its effect. The bill proposes to reorganize the Department of the Interior into a Department of Public Works, consolidating under one head all building of the Government, amounting to twenty per cent of the appropriations made by Congress. Hitherto this work has been done by thirty different bureaus, twelve to fifteen of them of an engineering character tucked away in various departments foreign to their work. Concentration in one bureau will promote efficiency and enable Government building to be done at much less expense. Instigated by the Engineering Council, the movement is now being carried on by an organization perfected at a conference of seventy-four different engineering societies. State organizations with state directors are now being formed to conduct a strong publicity campaign on the merits of the bill.

Power Plant Legislation

Legislation affecting the power plant more directly, in addition to that already mentioned, was the creation in Massachusetts of a Department of Public Safety, organized into three divisions and incorporating the Board of Boiler Rules, boiler and building inspection and the examination and licensing of engineers and firemen into one of the three, known as the division of inspection. The repeal of the daylight saving law will have its effect on the general public as well as the power plant, unless general local action perpetuates in urban centers the advantages so evident during the war. There has been no indication of engineer's license legislation, but during the year bills for the legal adoption of the American Society of Mechanical Engineers' Boiler Code were introduced before state legislatures with the result that thirteen states have adopted the Code, namely: Massachusetts, Rhode Island, New York, New Jersey, Delaware, Pennsylvania, Ohio, Michigan, Indiana, Wisconsin, Minnesota, Missouri, Oklahoma and California.

The Honor Roll for 1919

During the year many received memorials for the excellent work they had done at home or abroad during the war or in the civil pursuits of life. The list is too extended for repetition and will be limited here to recipients closely connected with the power field. Early in the year Prof. Auguste C. E. Rateau, inventor of the Rateau turbine, was named a member of the Academie des Sciences. Major-General George Goethals was awarded the John Fritz medal in recognition of his distinction in the engineering profession and as the builder of the Panama Canal. At the recent annual meeting of the American Society of Mechanical Engineers a session was held in commemoration of the eightieth anniversary of the meeting of Cornelius De Lamater and Captain John Ericsson, their fifty years of service to this country and the thirtieth anniversary of their deaths. Fifteen technical societies and civic organizations were represented in the gathering. It is the intention to erect tablets in New York on the sites formerly occupied by the Phœnix Foundry and the De Lamater Iron Works,

in which both men did so much for naval architecture and industrial engineering. During the annual meeting of the Mechanical Engineers a memorial tablet was unveiled and is to be placed in the society's rooms as a tribute to Frederick Remsen Hutton, who did such effective work for the society in its early days. Also a memorial brochure was presented in remembrance of William Kent, best known as the author of the handbook bearing his name.

By the Institute of Electrical Engineers the Edison Medal was awarded to Benjmain G. Lamme for invention and development of electrical machinery. At the annual meeting of the society a memorial tablet erected in acknowledgment of the services of William D. Weaver to the Institute was unveiled, following an appreciation of his efforts toward establishing the great technical library now quartered in the Engineering Societies Building. To the family of Andrew Carnegie a resolution expressing sincere appreciation of his great contributions to the advancement of engineering was passed by the leading engineering societies of the country and duly forwarded. The honorary degree of Doctor of Engineering was conferred upon Rear Admiral Robert S. Griffin, Engineer-in-Chief of the United States Navy, by the Stevens Institute of Technology. B. H. Peck was awarded the Chanute Medal for the best paper presented to the Western Society of Engineers during the year previous, and announcement was made by the same society of the award of the Alvord Medal to Herbert C. Hoover, who had been chosen by a committee of the society as the engineer who had done most for the comfort and well-being of humanity.

Engineering societies closely related to the field, honored the following men with the presidencies: Fred J. Miller, American Society of Mechanical Engineers; Calvert Townley, American Institute of Electrical Engineers; R. H. Ballard, National Electric Light Association; John J. Calahan, National Association of Stationary Engineers; F. E. Matthews, American Society of Refrigerating Engineers; Walter S. Timmis, American Society of Heating and Ventilating Engineers.

Necrology

Several men of prominence in the field passed away during the year. In chronological order the columns of *Power* has record of the following: Professor Rolla C. Carpenter, long associated with Sibley College of Cornell University; Abram T. Baldwin, president of the Precision Instrument Company; Burt O. Gage, a prominent inventor and pump expert and superintendent of the Warren Steam Pump Company; Frederick L. Hickock, president of the Reliance Gauge Column Company; Malcolm Gifford, president of the Gifford-Wood Company; Capt. Charles H. Manning, for many years prominent in engineering circles in New England as chief engineer of the Amoskeag Manufacturing Company, the largest cotton mill in the world; Professor Charles B. Richards, Emeritus Professor of Mechanical Engineering at Yale; George H. Phillips, president and treasurer of the Hewes & Phillips Iron Works; William T. Wheeler, president of the Diamond Carbonating Company; Charles Edwin Knox, one of New York's leading consulting electrical engineers; Samuel T. Wellman, past president of the American Society of Mechanical Engineers and an inventor best known by his patents on the Wellman hydraulic crane and the Wellman open-hearth charging machine; Oscar Otto, latterly general superintendent of the South Philadelphia Machine Works of the Westinghouse Electric and Manufacturing Company; Frederick Sargent, senior member of the firm of Sargent & Lundy and one of the most prominent consulting engineers in the United States; Andrew Carnegie, the great ironmaster and philanthropist; Charles E. Lord, general patent attorney of the International Harvester Company and at the time of his death chairman of the Chicago Section of the American Society of Mechanical Engineers; Richard Hammond, former president of the Lake Erie Boiler Works and the Lake Erie Engineering Works; H. L. Gantt, well-known industrial engineer and author of several works on industrial management.

Relationship Between Specific Gravity and Heating Value of Crude Oils

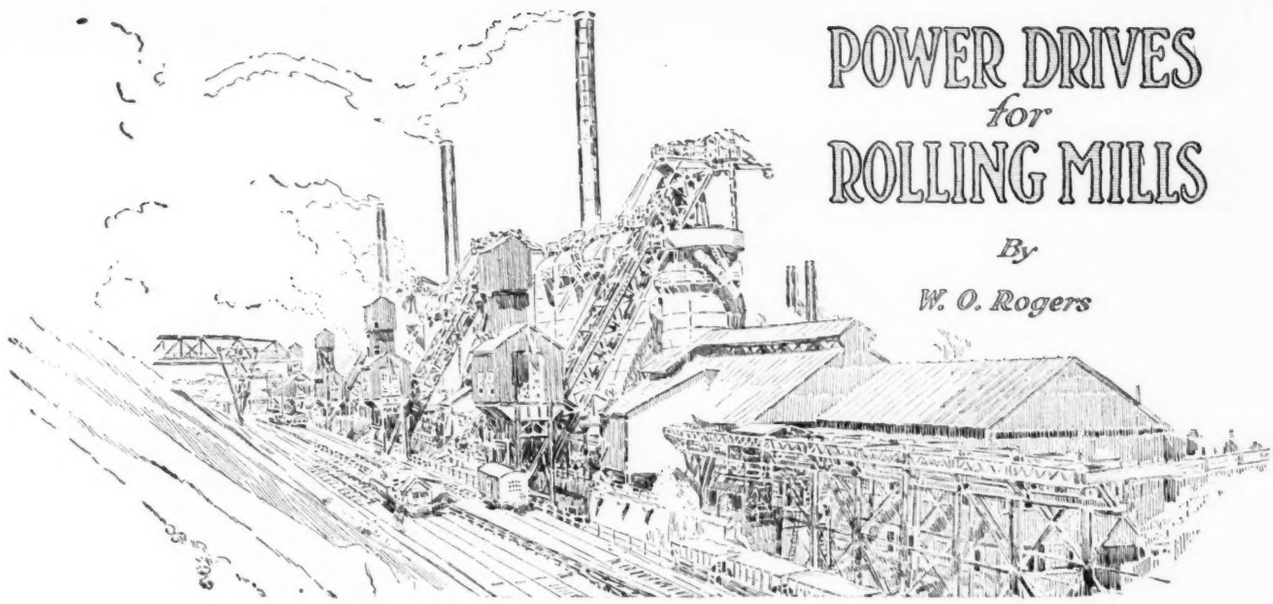
Speaking of tests conducted by Professor O'Neill, of the Department of Chemistry, University of California, C. R. Weymouth [Transactions A. S. M. E., Vol. 33, p. 68] says:

> It was found that there is no exact relationship between the specific gravity of crude oil and its hydrogen content, although there is a general tendency toward an increase in hydrogen content with a lighter oil. Examination of the ultimate analyses and calorimeter tests of a number of California oils indicates the rather startling fact that it is possible in oils having practically the same total quantity of inert constituents to have a variation in both hydrogen and carbon content with practically no variation in the calorific value of the oil.
>
> The inevitable conclusion that the calorific value of crude oil does not correspond to the heat of combustion of its elemental constituent and that formulas for calculating the total heat of fuels are not applicable to California crude oils is borne out by the fact that the calculated calorific value was, in one instance, 8.7 per cent. greater than that obtained from a calorimeter test.

While this relates to California oil, we have not seen anything to show that it does not equally apply to Mexican oil.

According to *Commerce Reports* it is announced that a great scheme of electricity supply for the north Midland counties is proposed, the chairman of the Nottingham corporation electricity committee having stated that government experts have recommended the erection of a superpower station on the banks of the Trent to meet the requirements of an area 50 miles north to south and 40 miles east to west, or 2000 square miles in all. Such area would include parts of the counties of Nottingham, Derby, Stafford and Leicester. The estimated cost of the first section is $25,549,125, while the whole scheme when complete is expected to require an outlay of $68,131,000. The ultimate annual saving to Nottingham tramways alone is put at $194,660. A further proposal, which is under inquiry by the Ministry of Health, relates to an application by the Manchester City Council for power to borrow $4,866,500 for extending its electricity works. In order to meet new calls for electricity for industrial purposes, it is stated that the extensions must be completed within three years.

In 1901 the first transmission line operating at a voltage above 70,000 was put into service. The use of high-voltage transmission has increased until today there are in this country and Canada about fifty companies operating systems at 70,000 volts and above. These systems represent an aggregate of approximately 14,000 miles of single-circuit line and have over 2,000,000 kw. of generating capacity connected to them.



POWER DRIVES for ROLLING MILLS

By W. O. Rogers

"I UNDERSTAND that Youngstown, Ohio, is a great steel town," I remarked to a fellow traveler as the train on which we were riding rushed on its way toward that city.

"Steel man?" he asked, knocking the ashes from the end of his cigar.

I replied that I was not, but that I would be interested in going through some of the mills if permission could be obtained.

"That's a proposition that you can't tell anything about until you try. Now, you would find it next to an impossibility to obtain permission to go through some of the largest steel plants in Pittsburgh and through some of the plants in Youngstown and surrounding towns; that is, those operated by these same companies. Why, I don't know, and I doubt if they can tell unless they don't want to be bothered having an outsider around their works. It surely can't be because they expect to keep out men who might come from other works in order to obtain information regarding manufacturing processes, because it is assumed that such are employed in every mill.

"I would advise you to visit the Youngstown Steel and Tube Co.'s plants, the Republic Iron and Steel Co.'s mills, the Sharon Steel Hoop and several other that are situated in surrounding towns. You will be pretty sure to get through these mills because they are progressive and are not afraid of a little publicity."

Seeing that I was interested, my new-found friend went on to tell me something about steel mills. "Of course, you know that the iron ore that comes from the mines of the iron country looks to the layman a good deal like brown dirt. This ore is put in a blast furnace (Fig. 1) with a certain amount of coke and limestone; that is, with, say, 300 tons of ore about 200 tons of coke and about 65 tons of limestone, although the amount of fuel and limestone depends upon the nature of the ore and the grade of iron wanted. These furnaces are around 70 to 100 ft. high and are equipped with inclined elevators, each having two counterbalaned cages, the empty one descending as the loaded one ascends. At the top of the furnace the coke, limestone and ore are automatically dumped into a hopper and fed to the furnace in the order named.

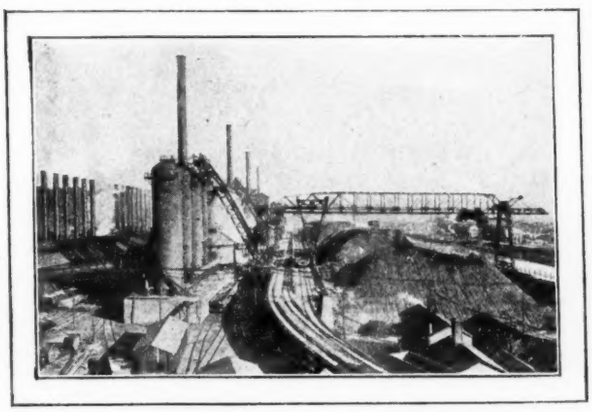


FIG. 1. BLAST FURNACE AND ORE BRIDGE, MAIN PLANT YOUNGSTOWN SHEET AND TUBE CO.

"Upon melting, the nonmetallic matter separates from the reduced iron and unites with the lime, and the flux being lighter than the iron, floats on its surface and is drawn off as slag, through a suitable hole, after which the iron is drawn out through a lower tap-hole into pig-iron molds, or it is conveyed in ladle cars either to the bessemer converter or to the open-hearth furnace.

"All material charged into a blast furnace passes out either as a liquid or as a gas. The gas that comes off at the top passes down into ovens and is burned there. The liquid products pass off as iron and slag. Pig iron is often heated in a puddling furnace at a temperature somewhat above its melting point. The puddling furnace is a reverberatory furnace and the flame plays over the metal. The impurities are gradually burned out, and the pure metal is collected by means of long iron rods manipulated by the puddlers. The metal comes from the furnace in a pasty condition in the form of irregular balls (Fig. 3) and is then run through a squeezer to remove the main portion of the slag. It is finally passed through a rolling mill (Fig. 4). This metal, however, contains too much slag for ordinary purposes and it is sheared, and after reheating it is again passed through

Coke fuel is not used as the heating me-

a rolling mill, thus making it purer, and it is generally known as wrought iron."

"This is all mighty interesting," I said as my friend employed himself in wiping his glasses. "I suppose that steel is produced in much the same manner?"

He did not reply for a moment and then said: "I might say that the most common processes in making steel are known as the bessemer and the open-hearth processes. A pig-iron blast furnace produces a product known as pig iron, which is sold to such concerns as do not have a blast furnace or when the ore is obtained at a distance from the mill. For instance, some of the iron mined in the Michigan iron country is made into pig iron for shipment close to the mines, although most of it goes to the various Lake ports in its natural state and is put through the blast furnace at the mills. In the instance of the steel mill at Sparrows Point, Md., the pig iron comes from Cuba, and it is doubtless cheaper to handle it in that way than to bring in the raw iron ore.

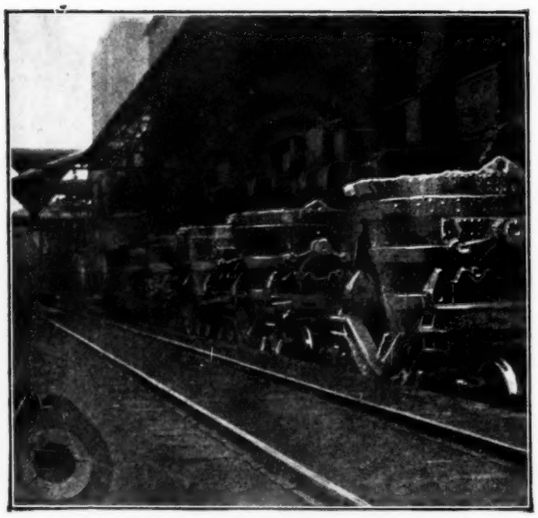


FIG. 2. METAL LADLES READY FOR FILLING WITH LIQUID METAL

"Well, after the iron has been treated in the blast furnace at a steel mill, it is run into huge ladle metal cars (Fig. 2) and is carried either to the bessemer converter or to the openhearth furnace."

"What is the bessemer process? I have heard of it and seen mills where a sheet of flame and sparks was being blown apparently through the roof and they said it was a bessemer converter. What is the idea?"

"In the bessemer process the hot pig metal from the blast furnace is poured from the metal cars, of which I already spoke, into the converter, and air is blown through it. This is to remove the impurities by the combustion of the silicon, manganese and carbon. This process requires from seven to fifteen minutes. Both bottom-and-side-blow vessels are employed, but the side-blow is used mostly in this country. The air is introduced through tuyeres in one side of the vessel, and the pressure used is around three or four pounds per square inch.

"When charging, the vessel is tipped forward and the molten pig iron is charged in the proper amount. Then the converter is tilted back to an angle of five or six degrees and the air blast is turned on. You will first see a few sparks come from the mouth of the converter and after three or four minutes of blowing a slight flame will appear at the mouth. The vessel is in the meantime being slowly turned toward a vertical position and after from five to fifteen minutes the flame and sparks are shooting out at a greater rate. That is what you have seen, as you just mentioned."

"What is to prevent the metal from being blown out with the slag, sparks, etc.?" I asked.

"That is taken care of by reducing the air pressure as low as possible when the 'boil' takes place; but if the air pressure is reduced below about 1¼ lb., the metal or slag will run into the windbox."

"How does the operator know when the metal has been sufficiently heated?"

"An experienced blower can generally tell when the final flame has been had, but if he is not sure the vessel is turned down and the metal is inspected. If the last flame has occurred and the carbon has been eliminated, the metal and slag lie quiet and flat in the converter without bubbling, but if there is still carbon in the metal the slag boils somewhat."

"What happens after the metal has been blown sufficiently?" I next asked, as I handed out a cigar that cost two for a quarter, but probably formerly sold two for a nickel.

"It is formed into ingot molds," replied my friend as he suspiciously gazed at the cigar I had given him. "These ingots are heated and then run through rolling mills. You will see them if you can obtain permission to go through any of the works."

"You spoke of the openhearth process. How does that operate?"

"In the openhearth process scrap steel and some pig iron are melted in a bath type of furnace, and the carbon, silicon and manganese are oxidized out of the metal by means of certain additions of iron ore. Nearly pure iron is obtained in this type of furnace.

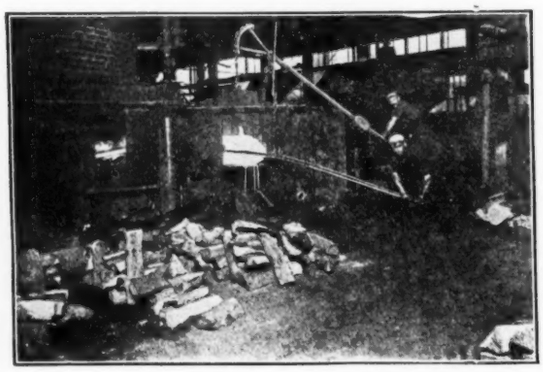


FIG. 3. PUDDLE FURNACE AND CAHALL WASTE-HEAT BOILER

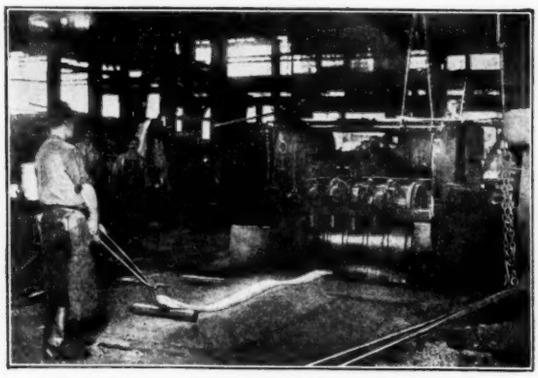


FIG. 4. ROLLING PUDDLED IRON

the reverse of gas and air flow can be had by the use of

to the defendant, but on the admitted facts the injury

Coke fuel is not used as the heating medium, but instead producer gas or natural gas. Fuel oil can be used, and experiments have been made with powdered coal. However, whatever fuel is used the method of working and the conditions in an openhearth furnace are about the same."

"You mentioned that pig iron is put into the furnace with scrap steel. Doesn't that make a metal of less purity?"

"If the furnace metal is to be properly heated, it is necessary that it should bubble. The pig iron assists in this because it produces the essential carbon, but only enough pig iron is used to bring the carbon down to about what is required in the finished steel.

"With openhearth furnaces two processes are used, the acid and the basic. In either the steel is low in carbon and must be recarbonized by means of proper agents, as I have just stated. The process is carried on in either stationary or tilting furnaces, and some of the stationary furnaces have a capacity of 200 tons. It requires from six to twelve hours to run a heat."

"What is the difference in operation between a tilting and a stationary furnace?" I asked at this point of the conversation.

"The tilting furnace is tilted forward on rockers, similar to the motion of a rocking chair. The stationary furnace, as the name implies, does not move, but the metal is drawn from it through plugged tap holes into huge ladles, from which it is poured into ingot molds."

In Figs. 5 and 6 are shown the charging and tapping side of a 100-ton capacity openhearth furnace at the main plant of the Youngstown Sheet and Tube Co., which plant I visited later on, and many of the illustrations in this and following articles are reproduced through the courtesy of that company and of the Republic Iron and Steel Co.

"You spoke of acid and basic openhearth steel," I remarked as the train stopped at a station. "What is the difference?"

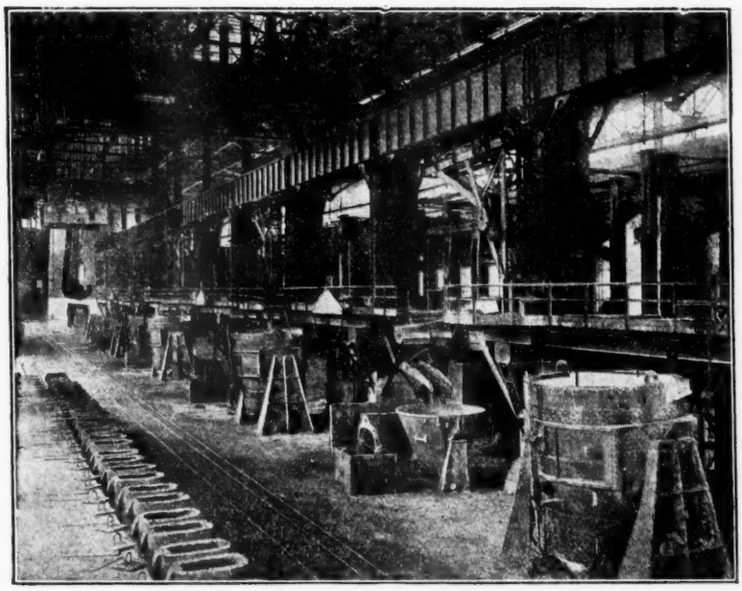


FIG. 6. GENERAL VIEW OF POURING FLOOR, OPENHEARTH FURNACE

"In acid openhearth steel the charge consists of pig iron and ore or pig iron and scrap having a low phosphorus content, and is melted in an openhearth furnace with an acid or siliceous lining. In the process the impurities in the pig iron are removed to a great extent by means of an oxidizing flame that is brought about by the mingling of producer gas and preheated air in a reverberatory regenerative furnace similar to the puddling-furnace process in making wrought iron; but the furnace temperature is carried much higher, and both the metal and the slag become molten.

"In making basic openhearth steel, the charge of either melted or pig iron or a mixture of pig iron and low carbon scrap is heated in a furnace similar to that used with the acid furnace, the lining, however, being of dolomite, lime magnesite or other basic material."

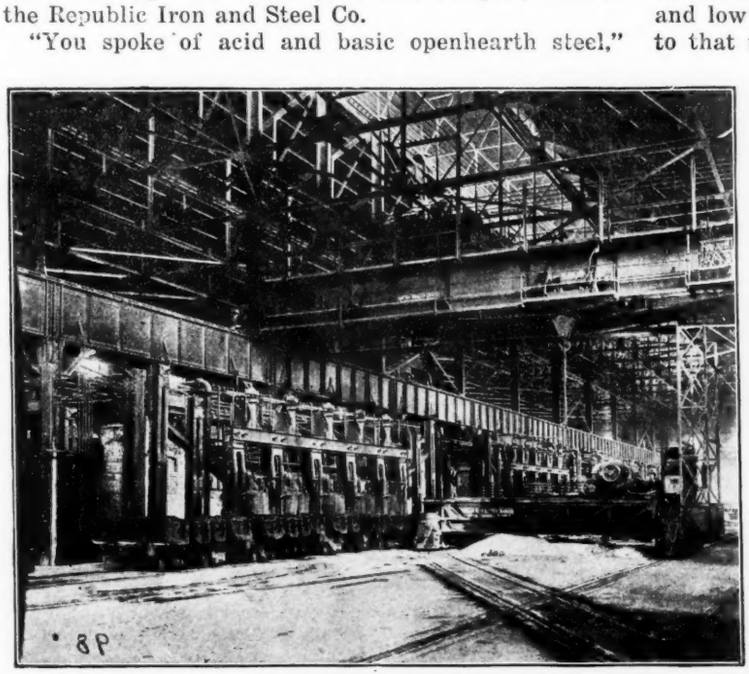


FIG. 5. A 100-TON OPENHEARTH FURNACE, SHOWING CHARGING CRANE AND CHARGING BOXES

"I don't quite get the idea regarding the application of the gas and air to the furnace."

"I'll try to make that plain to you," replied my companion. "The main parts of a regenerative furnace are the inclosed chamber or the hearth, the bottom of which is lined with refractory material, where the flame is produced and heats the charge of metal; the regenerative chambers, where the air is preheated, which are filled with brick checkerwork, and where the heat of the products of combustion leaving the hearth is absorbed, to be returned to the incoming gas and air when the direction of flow is reversed.

"For instance, gas from the gas producer is conducted through a suitable passage to a gas generator and is then conducted to the furnace at a point above the surface of the molten metal. Air also passes through an air regenerator, where it is heated, and is then delivered to the furnace with the gas. The gas burns, and the hot flame passes through a second set of gas and air generators, and

the reverse of gas and air flow can be had by the use of a reversing valve. The gas and air are heated to about 1000 deg. before entering the combustion chamber.

"Of course I have hardly hit the high spots relating to blast furnaces, and the subject would require many books to cover, but I think I have given you an idea of what the process is and that was what you was after."

"You have been mighty interesting," I replied. "As I understand it, the bessemer process handles pig iron only and the openhearth handles pig and scrap. The products of both are poured into ingot molds and while hot are put through a blooming mill."

"That's about it," answered my friend, as he arose to get his hat, the train having slowed down for his station.

"There is one thing I don't understand and that is the charging of the openhearth furnace," I said as I went to the platform to bid him goodby.

"That is easily explained," was the answer. "A charging crane is used (Fig. 5). The crane runs on a very wide-gage track and is electrically operated. In front of the charging end of the furnace is another track on which cars run carrying the charging box. The crane is run along in front of these cars, an extension arm is run out and the head of the arm engaged with a suitably formed coupling head on the end of the charging box. The arm and box of metal are then elevated sufficiently to come in line with the furnace door, which is then opened and the arm with the charging box on the end is run into the furnace. Then it is turned half over and the contents of the box dropped into the furnace, after which the arm and box are turned back to their original position, the arm is withdrawn and the charging box is replaced on its car ready for hauling away for another load of scrap iron."

I returned to my seat as the train started on its way and in a short time reached my destination, Youngstown, where later, I saw most of the process of which my casual acquaintance had explained.

Contributory Negligence of Engineers

BY A. L. H. STREET

Plaintiff, as day engineer at the defendant's plant, mounted a ladder to make repairs on some steam pipes. The ladder slipped and he was injured. Suing for damages, he asserted negligence on the part of defendant employer in failing to provide a ladder so spiked as to avoid slipping. At the trial it was shown that the ladder was spiked at one end, and that the night before the accident the plaintiff had left the ladder in proper position. But during the night another employee used it in another place and then returned it wrong end up.

Denying the plaintiff's right to recover damages on the ground that plaintiff's own contributory negligence in failing to assure himself that the ladder was properly secured against slipping barred any valid claim on his part, the Pennsylvania Supreme Court says in the case of Finan vs. F. T. Mason Co., 107 Atlantic Reporter, 692:

> An employer is bound to protect his employee from danger reasonably to be apprehended, but not against all possible danger, and least of all against danger occasioned by the employee's own negligence. Not only did the evidence come short of showing negligence chargeable to the defendant, but on the admitted facts the injury complained of was traceable directly to the plaintiff's negligence in failing to examine the position of the ladder before ascending it.

Measuring Diesel-Engine Crankpin Clearance

BY L. H. MORRISON

The average operator of Diesel engines "jumps" the connecting-rod big-end to determine the crankpin clearance. This is open to the objection that the result obtained is comparative, not exact.

To secure an accurate determination of pin clearance, either of two methods can be adopted. In Fig. 1, which outlines a big-end bearing and crankpin, a lead wire *B*, or soft soldering wire, about ⅛ in. in diameter, is inserted in the bearing between the pin and the babbitt. The bolts are next tightened until the halves of the bearing meet on the shims, or distance pieces, at the junctions *AA*. After loosening the bolts, the wire, which has been flattened in the tightening process, is

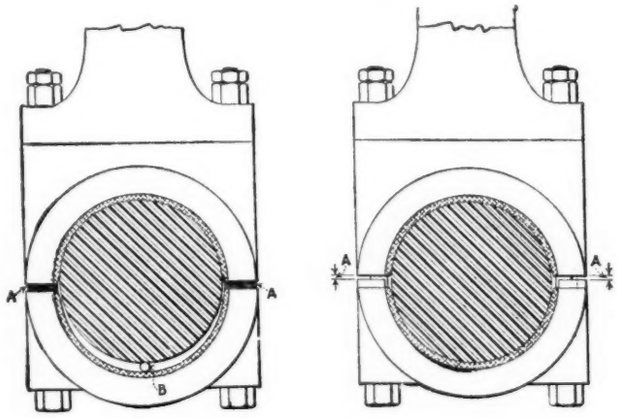


Fig. 1. By Lead Wire Fig. 2. By Thickness Gage

METHOD OF MEASURING CRANK PIN CLEARANCE

measured by a micrometer. If the thickness is not between 0.007 in. and 0.010 in., shims can be removed or inserted at *A* to bring the clearance to this value. The objection to this method lies in the difficulty of removing the wire. Usually, the pressure exerted on the bolts with the consequent flattening of the wire causes the latter to adhere to the crankpin so that it is almost impossible to remove the wire without lowering the bottom half of the bearing.

A second method is outlined in Fig. 2. Here the bolts are drawn up as tight as possible and the opening at *A* is measured by a thickness gage. This width plus the desirable clearance of 0.007 in. is equal to the thickness of shims, or distance pieces, that must be inserted. If the halves of the bearing come together without shims, the bearing needs rebabbitting. In rebabbitting it is highly desirable to have ample shimming between the two halves. One-half inch on each side is not too much, since that will allow considerable wear before the bearing need be rebabbitted again.

Not only has increased efficiency been secured in the burning of coal in the furnaces under oil stills, as a result of Bureau of Mines experiments, but a considerable percentage of increased capacity has been attained. The work has been done in co-operation with the Sinclair Oil Company.

Steam-Turbine Governors—Small Shaft Governors

This, the first article, describes methods of governing and considers the construction and adjustment of a few turbine governors of the shaft type.

METHODS OF GOVERNING TURBINES—The manner of governing steam turbines is in some respects similar to that employed for reciprocating engines, with the chief difference that for large turbines the governing mechanism is usually more complex.

There are three types of turbine governors commonly used. The throttling type uses a balanced throttle valve operated through links and levers by weights or springs moved by centrifugal force, throttling the admission of steam to a chest from which the steam flows to the turbine nozzles. Nearly all small turbines are governed in this manner, the governor proper being attached directly to the end of the mainshaft and known as a direct, or shaft, governor.

The second, or intermittent admission, method is exemplified in the Westinghouse and Parsons turbines. With this method of governing, the primary and secondary, or main, steam valves are held to their seats by springs and opened by the movement of pistons on the main-valve spindles, the pistons being actuated by steam or oil pressure admitted through relay valves.

The third method, wherein hydraulically moved relay valves or cams on a shaft operate a number of steam nozzle valves, as in the Curtis turbine, is a multiple-control method, or more correctly, control by a series of valves operated in rotation, for there are a number of poppet valves which admit steam to the nozzles. The chief advantage claimed for this manner of governing is that the working nozzles, or nozzles admitting initial pressure steam, do so continuously, thus they always work at highest efficiency.

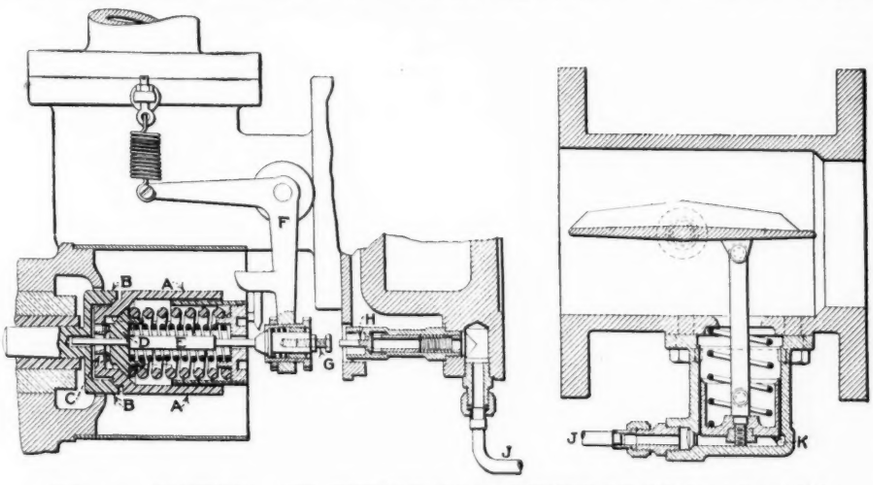


FIG. 1. GOVERNOR AND EMERGENCY GOVERNOR OF SMALL DE LAVAL STEAM TURBINES

De Laval Shaft Governor—In Fig. 1 is shown a sectional view of the shaft governor used on small De Laval turbines. This governor is mounted on the end of one of the gear shafts. (See Fig. 2.) Weights *AA*, Fig. 1, in the form of half-cylinders of bars, are mounted and hinged on knife-edges *BB*. The weights swing on their knife-edges and are held in place by two springs. As the speed increases, the weights fly out and cause the round-nosed pins *C* to move forward against the collar *D*, the action of centrifugal force in throwing out the weights being resisted by the springs. As the springs are compressed, the collar *D* pushes against the shoulder of the spindle *E*, which moves the bell crank *F* operating the balanced throttle valve, Fig. 3. There is a

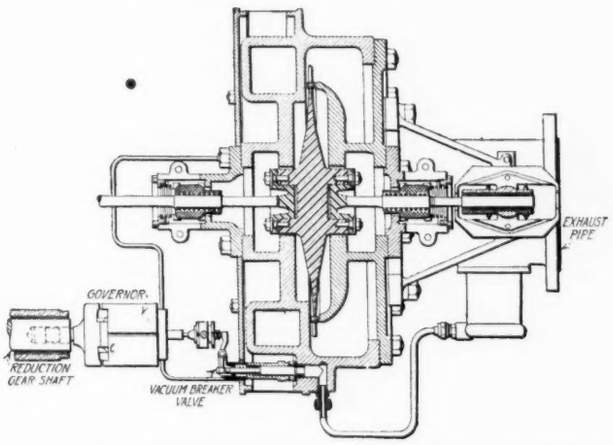


FIG. 2. TURBINE WHEEL, GOVERNOR AND ITS CONNECTIONS—SMALL DE LAVAL MACHINE

certain amount of "play" at *F* to reduce the amount of valve opening. In some sizes of turbines it requires but ⅛-in. movement of the spindle *E* to move the valve from full open to complete closure. The bell crank is balanced by a spring, as shown. The governor regulation is supplemented by hand-operated nozzle valves, shown in Fig. 4, which admit additional steam to the wheel during overloads.

De Laval Emergency Governors—Turbines designed to be run condensing cannot be operated against a relatively high back pressure. This fact is made use of in some of the De Laval machines. Referring to Fig. 1, it will be seen that there is an adjustable projection *G* that moves in and out with the spindle. In case the speed should increase beyond that predetermined, the projection *G* will move out, push open a valve *H* which admits air to the condenser through the hollow spindle of the valve, through the pipe *J* to the piston *K*.

In other types of small De Laval turbines the shaft governor is like the one described above, but the emergency stop consists chiefly of a butterfly valve in the exhaust pipe operated by the governor after the turbine has exceeded a predetermined speed.

The Kerr governor is indeed simple and in general like most shaft governors. The throw of the weights by centrifugal force is resisted by a heavy spring. The weights are in the form of half-cylinders, machined from a solid piece and split. They swing on hardened-steel knife-edges which are detachable. Those parts of

the weights which push the spindle forward do so by making a rolling contact.

The spring on the governor-valve spindle tends to hold the valve open and resists the closing effort of the

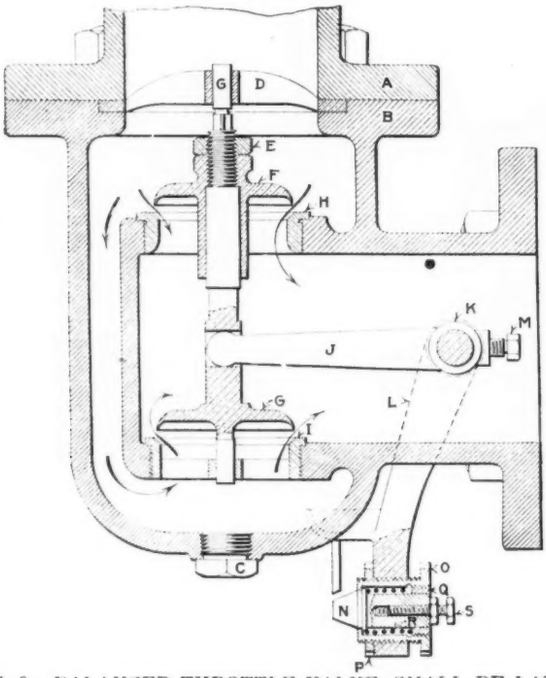


FIG. 3. BALANCED THROTTLE VALVE, SMALL DE LAVAL TURBINES

governor. To obtain slight speed variations, the compression of this spring may be increased or decreased. Normally, the governor is adjusted for faster or slower speeds by increasing or diminishing the compression of the main spring by screwing a nut down on or away from the spring. The spindle is well provided with oil channels for adequate lubrication. No emergency stop is provided, it being considered that the governor will always function to prevent excessive speeds.

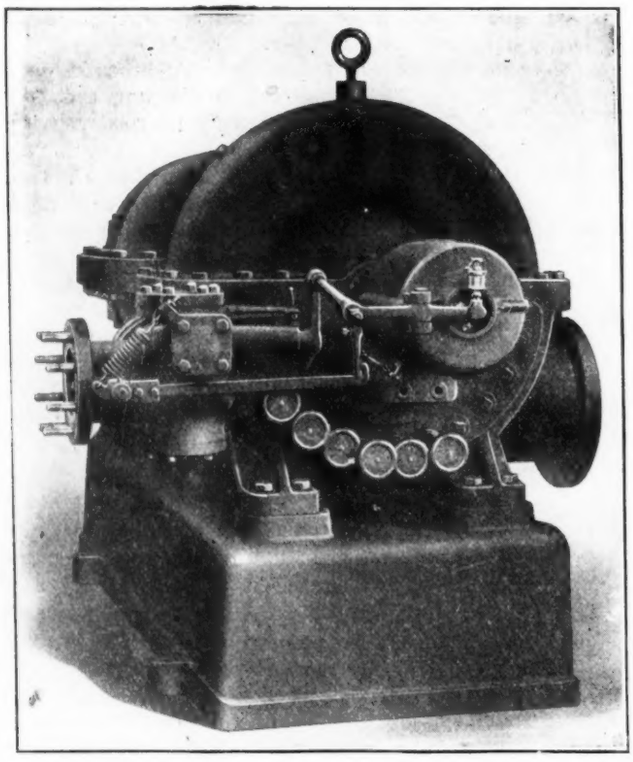


FIG. 4. GOVERNOR END OF SMALL DE LAVAL TURBINE

The small handwheels in front are used to open valves admitting more high pressure steam to the wheel to handle heavy loads.

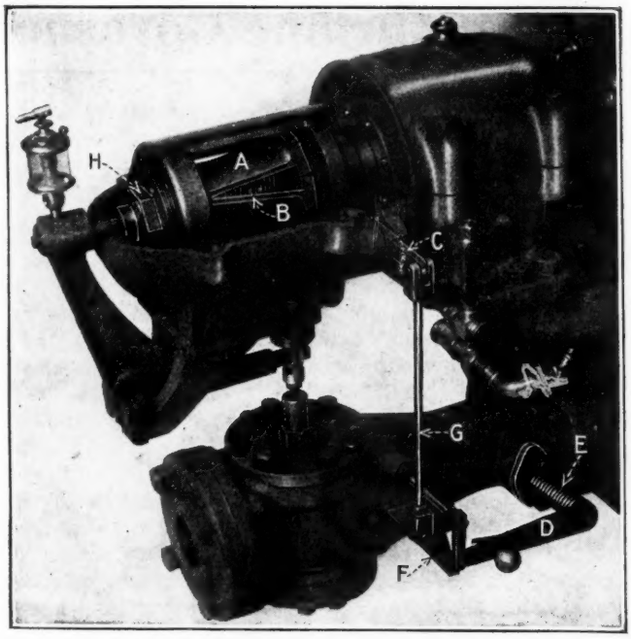


FIG. 5. LOOKING DOWN ON GOVERNOR AND GOVERNOR VALVE, STURTEVANT TURBINE

Sturtevant Turbine Governors—All Sturtevant turbines are provided with direct-type governors mounted on the end of the mainshafts. An emergency stop, independent of the main governor, prevents excessive speed.

Fig. 7 is a sectional elevation of a Sturtevant turbine, showing the relative position of the governor mechanism to the rest of the machine. As shown, the motion of the governor spindle is transmitted to the regulating valve through one bell crank, no other connecting levers being used. The illustration shows that the emergency stop valve *A* is of the butterfly type.

Fig. 5 is a view looking down on the governor mechanism, the top half of the casing having been removed. As the weights *A* and *B* are thrown out against the tension of a spring between them and on the spindle, the spindle is pushed forward, moving out the bell crank, lifting the regulating-valve stem and disks and decreasing the flow of steam to the turbine. Notice that the bell crank is pivoted on knife-edges, which should not be oiled. An oil cup drops oil to the end of the bell crank and the spindle. The centrifugal force

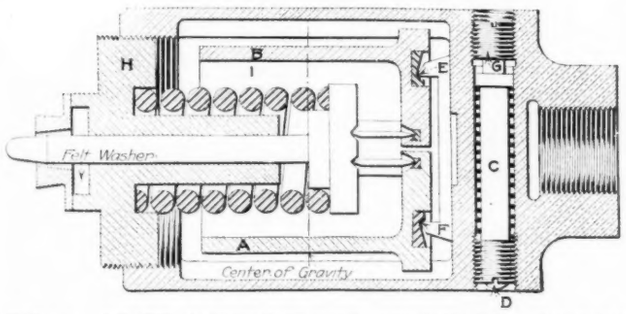


FIG. 6. SHAFT GOVERNOR FOR STURTEVANT TURBINE

auses the oil to flow along the spindle to a felt washer, shown in Fig. 6.

The Emergency Governor—As stated, the emergency governor valve is of the butterfly variety, placed between the regulating valve and casing. It is spring-loaded and held open by a notched bell crank, as shown in Fig. 5. Referring to Fig. 6, a bolt *C* is held in the casing (at a point *C*, Fig. 8) by a helical spring, and a threaded plug at one end of the hole. Should the regulating governor be deranged, the bolt will begin to move out of the casing at *D*, Fig. 6, when the speed has increased to about 8 per cent. above normal, and at 10 per cent overspeed will fly out and strike the inner end of the lever *C*, Fig. 5, which will release the resetting lever *D*, allowing the spring *E* to close the emergency valve and stop turbine. After the throttle has been closed, reset the emergency governor, a knob-handle being provided to assist in raising the resetting lever. Adjust the emergency governor when necessary by screwing in the plug *G*, Fig. 6, to make the governor more sluggish and screw it out to make it operate at less overspeed.

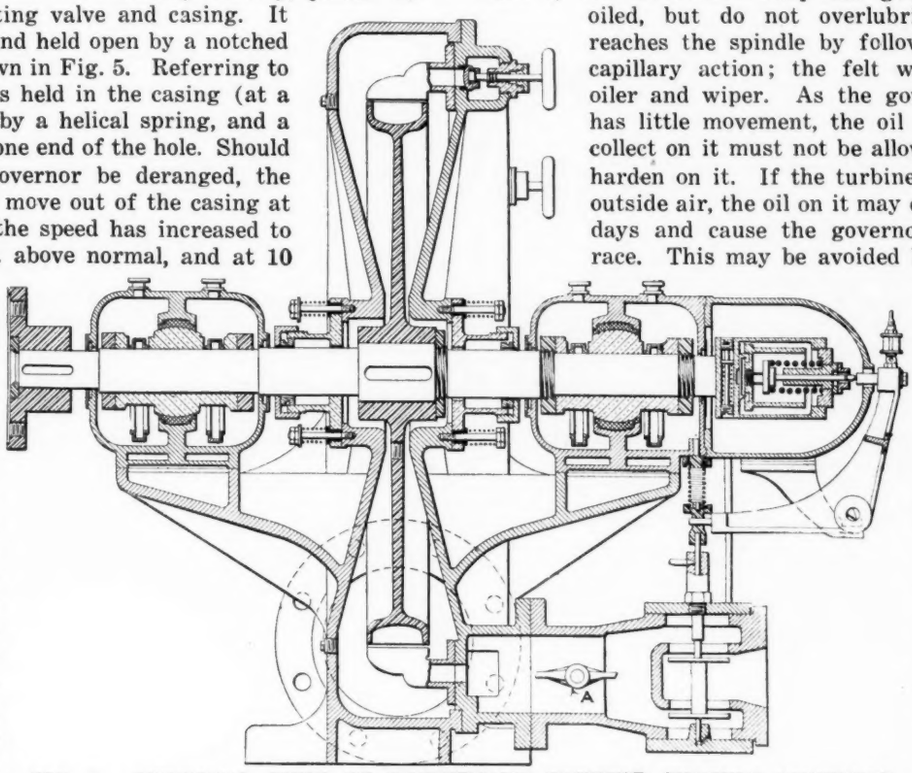


FIG. 7. SECTIONAL VIEW OF STURTEVANT TURBINE, SHOWING GOVERNOR

To prevent chattering of the emergency gear, a spring *F*, Fig. 5, rests against the bell-crank trip.

The weights are mounted on knife-edges at *E* and *F*, Fig. 6 (*D* and *E*, Fig. 8) and the spindle rests on knife-edges *J* and *K* (*F* and *G*, Fig. 8). Do not oil these knife-edges, for if oiled they may gather dirt and wear rapidly.

To increase the speed of the turbine, increase the compression of the spring by screwing in *H*, Figs. 5, 6 and 8; to decrease the speed, decrease the compression of the spring. In making adjustments to governors it is always well to go slowly.

Care of the Governor—Keep the governor spindle oiled, but do not overlubricate it. Oil reaches the spindle by following along by capillary action; the felt washer acts as oiler and wiper. As the governor spindle has little movement, the oil and dust that collect on it must not be allowed to gum or harden on it. If the turbine is exposed to outside air, the oil on it may congeal on cold days and cause the governor to jump or race. This may be avoided by moving the spindle in and out a few times by hand before starting the turbine.

At the end of runs stop the turbine by releasing the emergency valve. If this is not done, the stem may become so fast in the stuffing-box that the spring will not turn it when the resetting lever is released on overspeed.

No packing is used in the stuffing-box on the regulating valve. The stem is made a close fit in the box, which is quite long; leakage of steam around the stem is usually slight and an indication that there is sufficient clearance. Sometimes, when using superheated steam, the stem expands and sticks in the stuffing-box.

The regulating valve disks are not intended to fit tightly on their seats, but to reduce the area of valve opening enough to regulate the speed of the machine. The seats and ports are large in diameter and lift about $\frac{1}{16}$ in. from their seats. Of course when the governor weights fly all the way out, the valve should be closed.

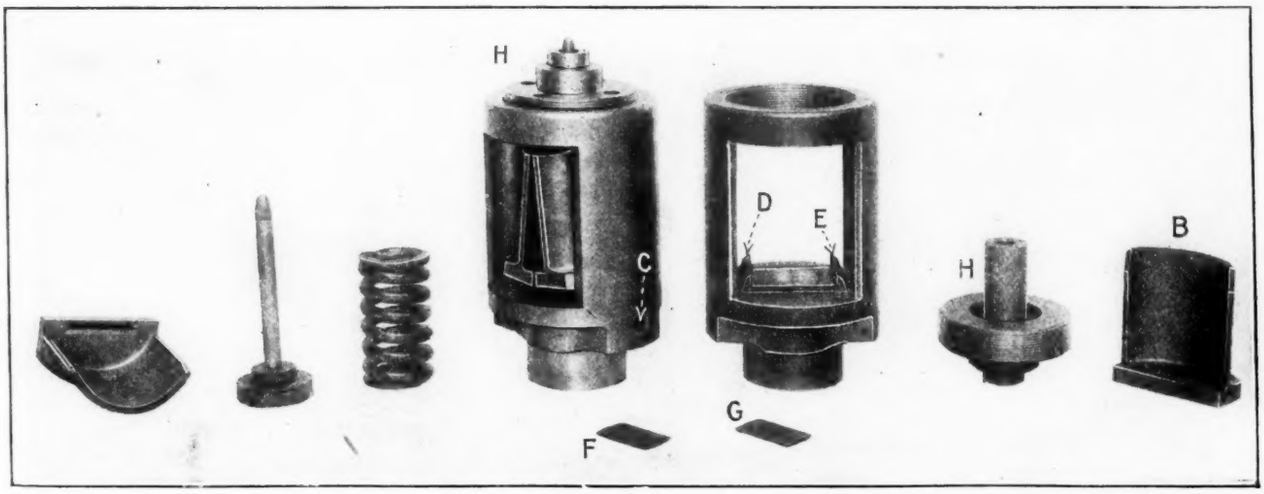


FIG. 8. THE SHAFT GOVERNOR OF THE STURTEVANT TURBINE, ASSEMBLED AND DISMANTLED

The Cost of Low Power Factor

By WILL BROWN
Engineer with the Electric Machinery Company

By using synchronous motors to correct power factor, large savings can be made in the cost of power, generator capacity and copper loss. Even in small systems it is now profitable to correct power factor, and the place to do it is at the motor end of the line. Pump and water-pipe diagrams make the article easy to understand.

THERE is a certain amount of lagging reactive kv.-a. (kilovolt-amperes) in every alternating-current power circuit where power factor is less than unity. In the analogies given in the previous article, "The Flow of Wattless Current Explained," in the Sept. 30 issue, the lagging reactive kv.-a. is the water flowing in and out of chamber *C*. A synchronous motor can supply leading reactive kv.-a., which raises the system power factor, and at the same time this motor can carry a power load measured in kilowatts. The economical feature about this is that the motor can supply almost as much leading reactive kv.-a. and at the same time carry a large percentage of its rated mechanical load, as it could if the full capacity of the motor was used to correct power factor or for driving a mechanical load alone.

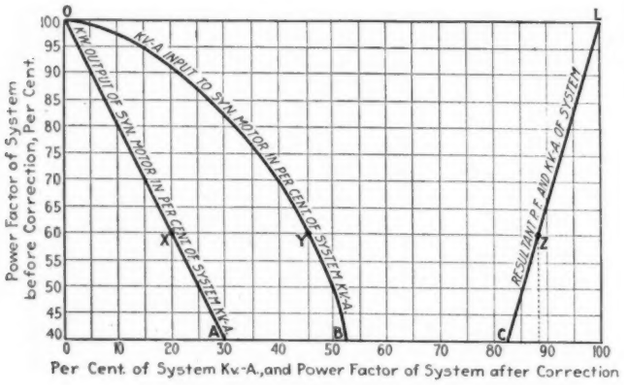

Power Factor of System before Correction, Per Cent.
KW. OUTPUT OF SYN. MOTOR IN PER CENT OF SYSTEM KV-A
KV-A INPUT TO SYN. MOTOR IN PER CENT OF SYSTEM KV-A
RESULTANT P.F. AND KV-A. OF SYSTEM
O
L
X
Y
Z
A
B
C
Per Cent. of System Kv-A., and Power Factor of System after Correction

FIG. 1. CURVES FOR ESTIMATING THE SIZE OF SYNCHRONOUS MOTOR TO INSTALL

For example, a synchronous motor with a rated capacity of 142 kv.-a. can furnish 100 reactive kv.-a. (leading) and also carry a mechanical load of 100 kw. On the other hand, if it is desirable that the motor carry the largest possible mechanical load, it can be operated at unity power factor, carrying 142 kilowatts, and no reactive kilovolt-amperes. The motor that is to operate at unity power factor can be built at less expense than one of the same capacity to operate at low leading power factor. There is less material used in the former case and the exciter is of smaller size.

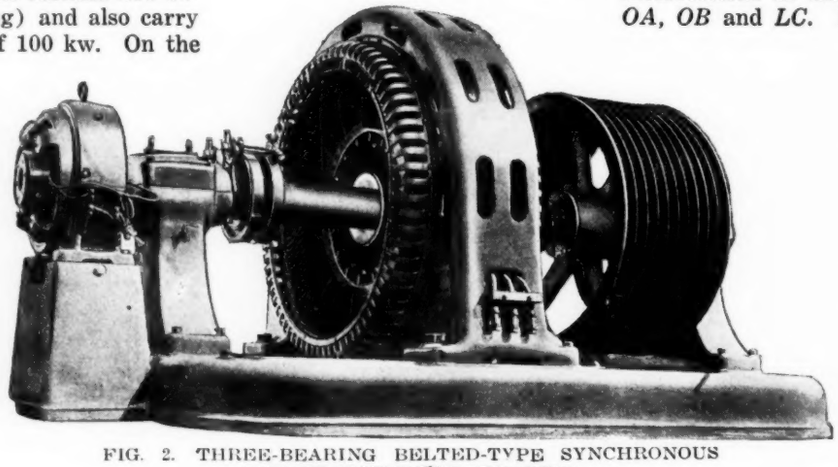


FIG. 2. THREE-BEARING BELTED-TYPE SYNCHRONOUS DIRECT-CONNECTED EXCITER

Every synchronous motor requires direct current to energize its field windings—much the same as an alternator. An exciter, it is true, is an added complication but by no means a serious one. Any operator who has handled direct-current motors will see no great difficulty in a direct-current generator with a rheostat in series with its field windings. After an operator has seen these exciters operate for years with hardly any expense beyond the renewing of an occasional brush, exciter troubles cease to be something to worry over.

When a synchronous motor is supplying reactive kilovolt-amperes to the line, it is helping the whole system back to the generating station. That is the reason some power companies offer inducements to customers who will install synchronous motors and raise their power factor. As to how much low power factor costs consider the following case:

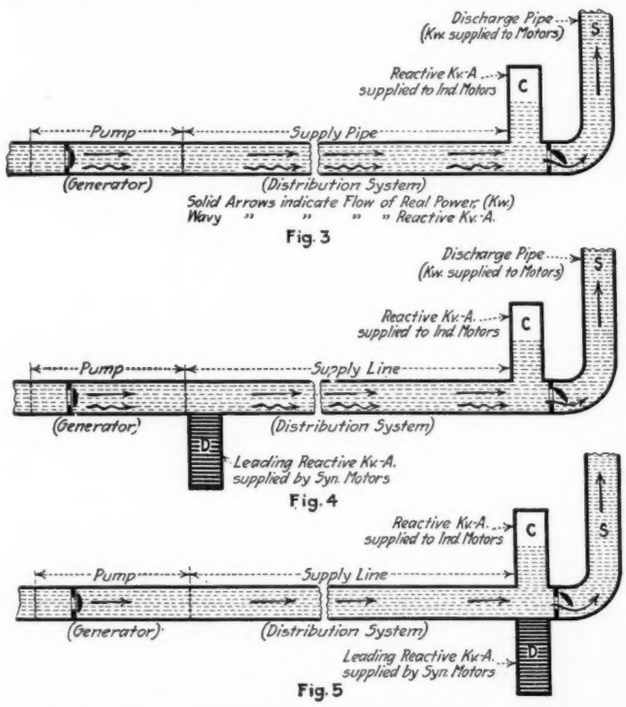
A 50-hp. induction motor consumed in one year a total of 83,000 kw.-hr., this being a load factor of 22 per cent. The power contract contained the following: "If the power factor of the energy taken is found to be less than 85 per cent., then the consumer shall pay for the electrical energy taken on the basis of 85 per cent. power factor. A further discount of 5 per cent. will be given to consumers installing synchronous motors."

The average power factor of the motor was 0.65, and the net power bill amounted to $1590. If this had been a synchronous motor, it would have met easily the requirements of 85 per cent. power factor and the bill would have been $1330. But in addition to this it would also have earned a bonus of $66.50, so that the net bill would have been $1263.50—a saving of $326.50 for one year's power bill on a 50-hp. motor that only averaged five hours and twenty minutes operation each day.

If the power factor and the kilovolt-amperes of a system are known, by the use of Fig. 1, the capacity of a synchronous motor to install can be found, which will give the maximum corrective effect to power factor while carrying mechanical load. On the vertical scale to the left locate the present power factor. From this point extend a horizontal line to the right and mark intersections of this line with curves *OA*, *OB* and *LC*. From these points of intersection drop vertical lines to the kv.-a. scale at the bottom. The point on curve *OA* will show the mechanical load in kilowatts that the synchronous motor can carry. The point on curve *OB* will show the kv.-a. capacity of the synchronous

motor. The point on curve *LC* will show the total kv.-a. of the system, also the new power factor of the system after such a synchronous motor has been added.

For example, suppose a line transmitting a load of 1000 kv.-a. is operating at 60 per cent. power factor; points *X Y* and *Z*, on the curves Fig. 1, determine answers to the following questions: What is the highest point we should try to raise the power factor of the line consistent with the economy of the apparatus? Answer, given by a vertical dropped from *Z* to the base line; namely, 88 per cent. power factor. What is the kv.-a. rating of the synchronous motor that will give this amount of correction? Answer, given by a vertical from *Y* to the base line; namely, 45 per cent. of the load on the system, in this problem $1000 \times 0.45 = 450$ kv.-a. What is the kilowatt load that the motor can carry, allowing the maximum correction for the system? Answer, given in per cent. of the kv.-a. load on the line



FIGS. 3 TO 5. HYDRAULIC ANALOGIES OF HOW THE LOW POWER FACTOR OF A LINE IS IMPROVED

by a vertical from *X* to the base line; namely, 20 per cent., or $1000 \times 0.20 = 200$ kilowatts.

In other words, the most economical thing to do would be to install a synchronous motor with a total kv.-a. rating of 450 and run it at a power factor of 44 per cent. leading, allowing it to carry 200 kw. mechanical load. As a result of this the power factor of the line would be raised to 88 per cent., the kv.-a. of the line would be reduced to 880 and the kilowatt load would be increased to 800 kw. The I^2R losses, voltage drop, etc., would be slightly less than in the original case when the system was carrying only 600 kw. For the method of finding the effects of combining the synchronous motor load with the line see article "A Simple Method of Determining Power-Factor Correction," published in *Power* June 15, 1919.

Low power factor of induction-motor loads has always been a source of trouble to power companies, but within the last year or two it has become such a serious proposition that most companies are preparing to enforce some kind of a penalty clause similar to that previously quoted. To a limited extent the power company can correct low power factor by installing large synchronous condensers in its substations, but the real place to correct power factor is right at the motors—the place where the low power factor is caused. In order to make this clear, consider again the pump and water-pipe diagrams. Fig. 3 indicates a pump and long supply pipe operating at lagging power factor due to the reactive chamber *C*. The power company is paid only for the water that passes through the discharge pipe *S*. But the company has to maintain a considerably larger pump and piping system to move all that excess water

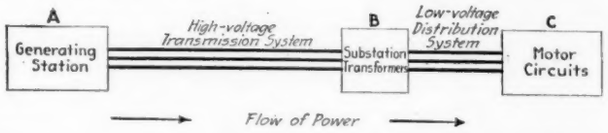


FIG. 6. DIAGRAM OF A GENERATION, TRANSMISSION DISTRIBUTION SYSTEM

when operating at low power factor. Also, there is an increased expense due to increased losses in the pump and pipes. In Fig. 4 the reactive chamber *D*, whose gas expands under pressure, as explained in the preceding article "The Flow of Wattless Current Explained," Sept. 30 issue, has been added to the line at a point near the pump. This corresponds to a synchronous motor operating at leading power factor placed in close proximity to the generators. Assuming that the action of this chamber exactly balances chamber *C*, the pump will be able to operate at 100 per cent. power factor, but the supply line or distribution system will still be at low power factor and burdened with the reactive current which flows back and forth between chamber *D* and chamber *C*.

Since there is a certain friction to every foot of pipe,

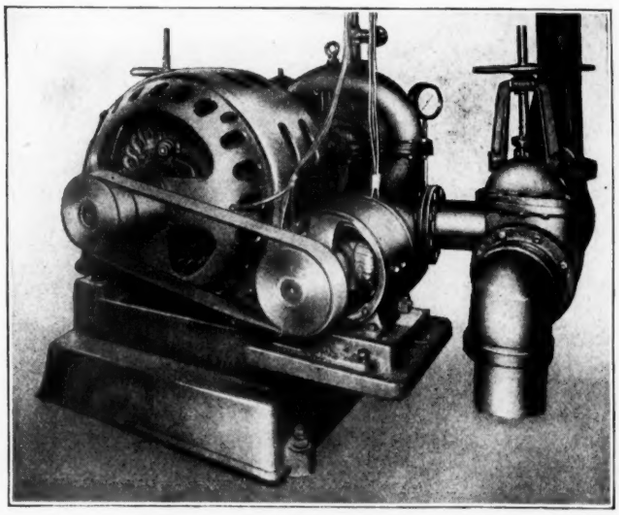


FIG. 7. SMALL SYNCHRONOUS MOTOR DRIVING CENTRIFUGAL PUMP

it is evident that there is considerable friction loss involved in moving this excess amount of water between *D* and *C*. This extra friction loss means a direct loss of power which must be made up by the prime mover driving pump.

In Fig. 5 the reactive chamber *D* is placed directly opposite chamber *C*. This corresponds to placing a syn-

chronous motor close to the induction-motor load. The pump is now operating at 100 per cent. power factor and so is the whole supply line. The reactive current flows back and forth between chamber *C* and chamber *D* and relieves the whole line of the excess water and friction loss. The whole line, including the pump, now operates at practically unity power factor with the minimum

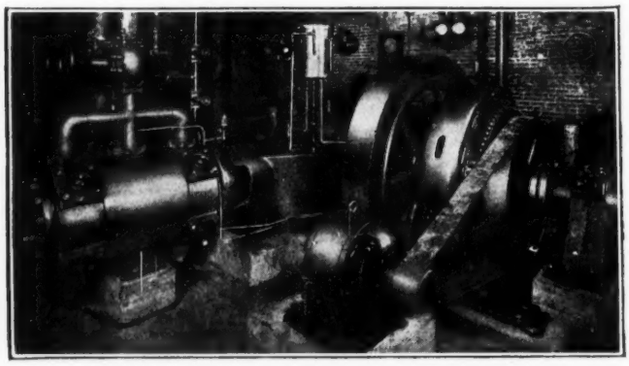


FIG. 8. ENGINE-TYPE SYNCHRONOUS MOTOR DRIVING AMMONIA COMPRESSOR

of losses. It is evidently very desirable to correct low power factor as close as possible to its source.

Fig. 6 represents a power system from the generating station to the motors. Distances between *A* and *B* and *B* and *C* will vary in different systems. Assume this system to be operating at lagging power factor. If synchronous condensers are placed at *A* the power factor of the generating station will be improved, but all the balance of the system from *A* to *C* will remain at as bad power factor as before. If the synchronous condensers are placed at *B*, the power factor will be raised from *B* inclusive back to *A*, but from *B* to *C* the low power factor will still prevail as before. If synchronous motors are placed at *C* (on the motor system), the power factor will be raised on the whole system from *C* clear back to *A*, and these motors can also be driving mechanical loads without seriously interfering with their capacity for correcting power factor. There is great saving when the power factor is corrected at the motor system *C* instead of at the transformer substation *B*.

To illustrate the extent of the copper losses due to low power factor on a certain system, when tests were made, the following facts were discovered:

The motor load was practically 7500 kw. The power factor at the substation (because of synchronous condensers installed there) was near unity, but on the distribution circuit it was 70 per cent. The watts loss, or copper loss, on this circuit at this power factor was 1900 kw. Later, synchronous motors replaced part of the induction motors and the power factor of the total motor load was raised to unity. The motor load remained practically at the same figure, 7500 kw., but the whole circuit now operated near unity power factor and the copper losses were reduced to 900 kilowatts.

Thus a saving of 1000 kw. was secured by raising the power factor of this 7500-kw. motor system and feeder circuit from 70 per cent. to 100 per cent. And it was no longer necessary to run the synchronous condensers at the substation. Assuming the system to operate at this figure for 4000 hours per year, the total saving would be 4,000,000 kw.-hr. If we say the cost of generating and delivering this wasted power to the feeder circuit averages 0.5c. per kw.-hr., the total amount saved in dollars would be $20,000. This represents an actual saving at the coal pile, for copper losses take power from the prime mover just the same as if useful work was performed. This, however, is only a part of the loss. The increase in overhead necessary to take care of large amounts of reactive current on a system, also the greater percentage of trouble and upkeep expense, the lowered efficiency due to poor voltage regulation and other results of poor power factor make up a heavy total. Furthermore, poor voltage regulation at the motors causes a reduction in production, and in some cases an inferior quality of material produced, either one of which may amount to losses of large proportions in a year's operation.

Is it practical for a power consumer to correct the power factor of his own load? A few years ago the answer would have been no, it could not be done except in the cases of large users of power. But the time is now at hand when it will be possible for the great majority of plants to raise the power factor if they wish to. Synchronous motors of 50-hp. and up can be used for driving certain classes of loads that have formerly been driven by induction motors. The efficiencies of such motors even at leading power factors will compare favorably with induction motors. Even if the load to be driven is less than 50 hp., it may be practical to use a synchronous motor. A motor of larger kilovolt-ampere capacity could be installed and the excess capacity used for supplying leading reactive kilovolt-amperes to the induction motors. There is a slight loss in efficiency, and the first cost will be higher but not at all prohibitive. In fact, the savings on the power bill will in many cases pay this difference within a short period. After that it may be considered that the synchronous motor is a source of revenue to any plant that was formerly running at low power factor. The net result will be that power will cost less on such a basis than under any other method. The importance of a more economical use of power is becoming of greater concern each year, since the cost of producing it is on the increase and there is small prospect of a change in this condition.

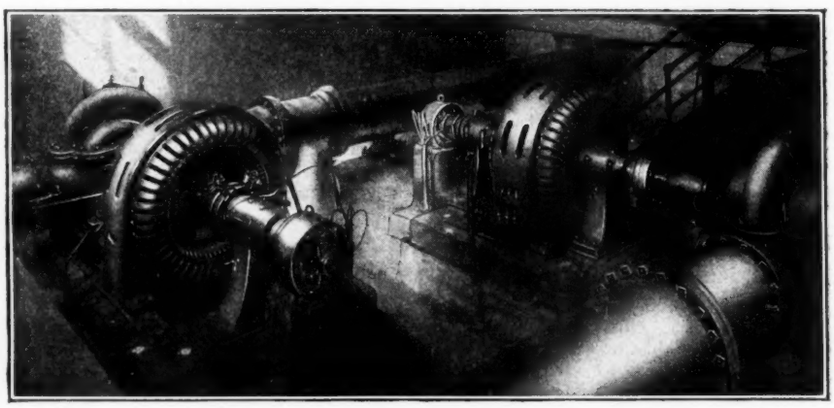


FIG. 3. SYNCHRONOUS MOTORS WITH DIRECT-CONNECTED EXCITERS DRIVING CENTRIFUGAL PUMPS

Boiler Explosion at Rockport, Texas

DETAILS have just become available concerning a boiler explosion which, although occurring several months past, presents features that make an account of it interesting. The boiler, a 72-in. horizontal return-tubular, was in use at Heldenfeld Bros. Ship Yards at Rockport, Tex., and exploded at

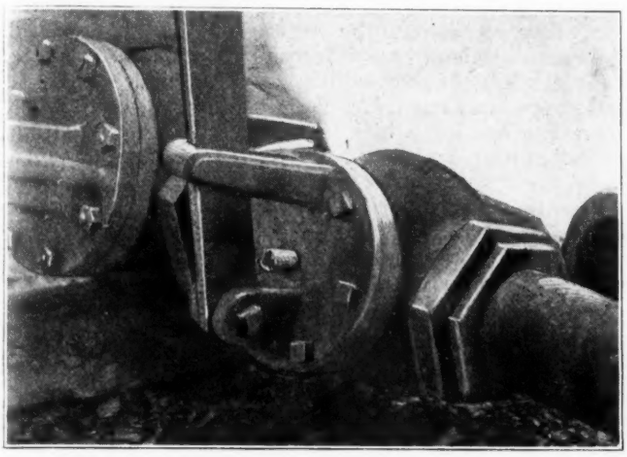


FIG. 1. SAFETY VALVE AFTER ACCIDENT

7:20 on the morning of July 29, 1919, killing four persons, slightly injuring one, and causing a partial destruction of the boiler plant.

This boiler had been in continuous operation for two weeks and on the night preceding the explosion was steaming and seemingly in good condition until about 3 a. m., when the grates dropped. This resulted in cutting the boiler out, but not before it was filled with water until the gage-glass registered within two inches of the top and which was blown down to see if it was in good condition. There was also another boiler operating in battery with this boiler which was kept in operation until the end of the watch at 6 a. m. It was about 5:30 before the boiler was cool enough to work on, and the work of reinstalling the grates took until 6. When the day crew came on, there was still about forty pounds of steam, with the water in the glass at about the same position; so stated the night engineer.

At this time in the morning, after changing watches, there was no one but the day power-house crew and the watchman on duty, as the workmen were admitted at 7:25. The watchman stated that he was on his way to the main entrance gate to let the workmen into the yards and on passing the power house, he stopped to say a few words to the day crew. Their positions, he says, were as follows: One of the firemen was sitting directly in front of the boiler reading a paper, the other was a little to one side, and back of him, sitting on the ground, a laborer was cleaning some ashes from the entrance, and the engineer was between the boiler that had been cut off the line and the one that was kept steaming, a space of about twelve feet, working with a boiler-feed pump. A few words were passed and he proceeded to the front entrance gate and was just in the act of removing the lock to let the workmen into the yard when the explosion occurred.

When the bodies were found, the engineer was where he was last seen by the watchman, one of the firemen was in the same place, and the other was over on top of the mill house, about 125 ft. away. The laborer was found about 15 ft. in front and to one side of the boiler that was still in operation at 6 o'clock. The boiler was blown about 650 ft. north of the yards, wrecking part of the boiler house, leaving the other boiler intact, with the exception that all of the steam lines were wrecked. A blacksmith shop standing about 50 ft. to the north was also partly wrecked.

As all the day crew were instantly killed, it is impossible to determine with exactness the condition immediately preceding the explosion. The examination of the boiler, however, found all seams, dome, braces and shell intact. The tube sheets were bulged and all the tubes were out of the front sheet and some of them projecting through the rear sheet, bent over; others were still in the same position, with the beads in good condition. The tubes were beaded over at the rear, while only expanded at the front. There was no evidence of any part of the boiler being overheated. On examination of the bulged tube sheets it was found that the metal between the tube holes was not fractured. The circumferential seam holding the tube sheets showed no evidence of fracture. The shell at this point was slightly turned down and the rivet holes not pulled. Every rivet tested in the boiler was tight. The bottom of the shell was buckled in at the front and gradually down from 3 to 14 in. at the rear.

There are two theories as the possible, if not probable, cause of the explosion. It is stated by the night crew, that at the time the boiler was cut out for repairs it had 105 lb. steam and was not even known to simmer or partly pop. It is also stated that previously there had been a pressure of 115 lb. and the pop valve did not work. It is probable that the other boiler was kept steaming, as only one boiler was needed at this time (which, it is stated, has happened before). The day crew, realizing the need of the second boiler on short

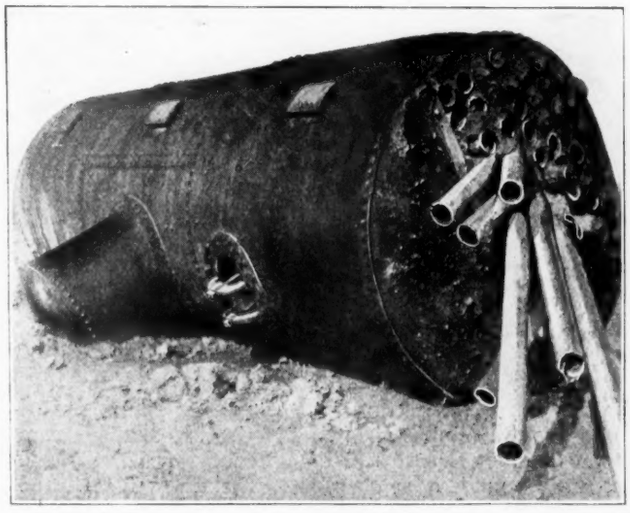


FIG. 2. TUBES PROJECTING THROUGH REAR SHEET

notice, started a heavy fire in it, and according to one of the night firemen's statements it would take about twenty minutes to again get 100 lb. or more of steam in the boiler. The day crew, in the same position as when last seen by the watchman only about three minutes before the explosion, forgetting the boiler, permitted excessive steam pressure to build up and upon noticing this condition, one of the firemen went on top of the boiler to make the ball-and-lever safety valve work,

and while trying to do so, the boiler blew up. This is the theory for the body of one of the firemen found on the mill-house roof. It is also probable that the day crew started a fire in the firebox when they came on duty. However, the owner, his superintendent and chief engineer stated that they saw the boiler pop the week previously, and one of the engineers said that he saw it pop the Saturday before the explosion. The superintendent asserts that he saw it pop on the morning of the day before the explosion. This is hardly possible, because on examination of the safety valve it was found that the valve stem, where it passes through the fulcrum or top of the valve body, was so corroded that it took a small sledge hammer to move it in either direction. The corrosion was found to be of old origin and about $\frac{1}{32}$ in. all around the stem of the valve where it passed through the cage, in which condition it could not have worked for some time, besides having a 100-lb. weight at least two-thirds the way out on the lever.

The other theory is that the pressure was not equalized, and upon trying to cut the two boilers together with unequal pressure, the explosion occurred. The owner states that at one time previously, with the pressures unequal, the boilers were cut together, resulting in blowing the fusible plug. This theory of the explosion is hardly probable, if the condition of the stop valve as found and demonstrated by the owner was the same as at the time of the explosion. The valve being closed, he took hold of the valve-stem wheel and moved it about one inch, stating that that was the position in which it was found only a few minutes after the explosion. This, however, would not open the valve, as it required a one-eighth turn of the wheel before the slack was taken up between the stem and valve. It then had to be moved about one-sixteenth of a turn more before the valve left the seat, which was good evidence that it had never been open far enough to admit steam. The prevailing opinion, which seems to be logical, is that an excessive pressure caused the front tube sheet to bulge and pull off the tubes at front, as they were not beaded.

This boiler was not insured and had never been inspected except at the time of the purchase, which was about a year previously. The boiler was second-hand and about twelve years old.

Equivalent Evaporation

By J. S. A. JOHNSON

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ONE of the principal objects of a boiler test is to determine accurately the total heat absorbed by the water in the boiler. This quantity of heat may be expressed in common thermal units, but owing to the large numerical values that would be involved, a larger unit of heat is used in expressing boiler capacities. This new heat unit in the British system is

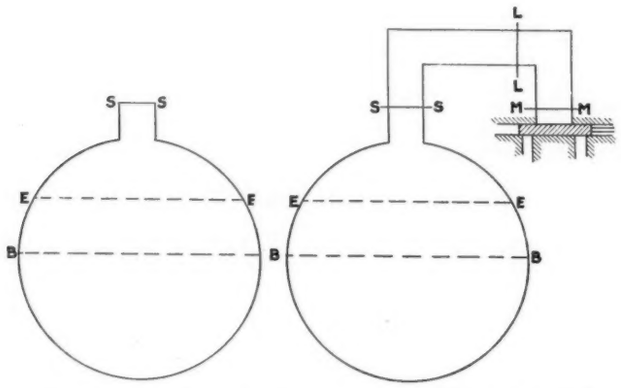


FIG. 1. WATER LEVELS IN CLOSED VESSEL

FIG. 2. WATER LEVELS IN BOILER

the amount of heat required to evaporate one pound of water from a temperature of 212 deg. F. to dry steam at the same temperature, being equal to 970.4 B.t.u. (recently found, it is claimed, to be 971.6 B.t.u), the B.t.u. being defined as $\frac{1}{180}$ of the total heat required to raise the temperature of one pound of water from 32 to 212 deg. F. The total heat absorbed by a boiler in terms of this larger unit is called the *equivalent evaporation*. It is the amount of water that would be evaporated to dry steam by the total heat actually absorbed by the boiler if the feed temperature, as well as that of the steam, were 212 deg. Therefore, to find the equivalent evaporation, the total heat in B.t.u. absorbed by the boiler is divided by 970.4.

As commonly stated, the equivalent evaporation is equal to the total feed water pumped into the boiler and apparently evaporated (corrected for difference in water levels at beginning and end of test), multiplied by a quantity called the "factor of evaporation."

In the new boiler code of the American Society of Mechanical Engineers equivalent evaporation "is obtained by multiplying the weight of water evaporated, corrected for moisture in the steam, by the 'factor of evaporation.' The latter equals $(H - h) \div 970.4$, in which H and h are respectively the total heat of saturated steam and of the feed water entering the boiler."

In order to correct for the quality of the steam, the following instructions are given in this code:

When the percentage of moisture is less than 2 per cent., it is sufficient merely to deduct the percentage from the weight of water fed, in which case the factor of correction for quality is

$$1 - \frac{\text{Per cent. moisture}}{100} \qquad (1)$$

When the percentage of moisture is greater than 2 per cent., or if extreme accuracy is required, the factor of correction is

$$1 - P\frac{H - h_1}{H - h} \qquad (2)$$

in which P is the proportion of moisture, H the total heat of 1 lb. of dry saturated steam, h_1 the heat in the water at the temperature of saturated steam, and h the heat in water at feed-water temperature.

When, therefore, the weight of water pumped into the boiler and apparently evaporated is multiplied by the product of the "correction factor for quality" and the "factor of evaporation," in other words, the product of expressions (1) and (2), the result is the equivalent evaporation according to the code's definition. Since $P = 1 - x$, the product of (1) and (2) is

$$\left\{1 - (1 - x)\frac{H - h_1}{H - h}\right\}\left\{\frac{H - h}{970.4}\right\}$$

Now since $H = L + h_1$ and $H_a = xL + h_1$, this expression may be simplified to read

$$\frac{H_a - h}{970.4} \qquad (3)$$

In these expressions x is the quality of the steam, L is the latent heat of evaporation and H_a is the total

actual heat of the steam (above 32 deg.), whether wet, dry or superheated. The other symbols have been already defined.

It will therefore be seen that the total equivalent evaporation is obtained from the expression,

$$W_e = \frac{H_a - h}{970.4} W_a \qquad (4)$$

in which W_e is the equivalent evaporation, and W_a the apparent evaporation. In this expression H_a is equal (a) $xL + h_1$; (b) $L + h$; (c) $L + h + m\ (T - T_s)$: for wet, dry and superheated steam respectively, where m is the mean specific heat of superheated steam, T the actual steam temperature and T_s the temperature of saturated steam at the pressure observed.

It is evident, therefore, that it is a waste of time, being confusing, to use for wet steam the method recommended in the code. No distinction should be made between the *forms* of expression for the equivalent evaporation for wet, dry or superheated steam, the general expression applying to all cases.

"Factor of evaporation" should therefore be defined as the total actual heat of one pound of steam (wet, dry or superheated) above the feed temperature divided by 970.4. When, however, the water levels and steam pressures are not the same at the beginning and end of the test, none of the expressions referred to gives the true value for the heat absorbed by the boiler, for the reason that none takes into account accurately the heat of the liquid above feed temperature of the weight of water represented by this difference in level, as well as other quantities of heat.

When the water level at the end is higher than at the beginning of the test, it is evident that more water has been pumped into the boiler than has been evaporated, but the temperature of *all* this water has been raised to the boiling point. If, on the other hand, the level be lower at the end than at the beginning, more water will have been evaporated than pumped in, but the temperature of all this has not been raised from the feed-water temperature. The weight represented by the difference of level in this case will have been supplied with only the heat of vaporization.

It is a matter of some importance and considerable interest to consider that weight of water is represented by the difference in level at the beginning and the end of a test. When, for instance, the level is higher at the end, the excess of water supplied to the boiler over that evaporated will be the volume between the two levels multiplied by the specific weight of water at boiler temperature, minus the same volume multiplied by the specific weight of steam at boiler pressure. The corrections must include not only the heat of the liquid of the excess above feed temperature which is to be added, but also the latent heat of vaporization of the steam which originally filled this space, which amount of heat is to be subtracted since the steam was condensed. This conclusion follows from the fact that if water is pumped into a closed vessel containing water and steam, the pressure being constant, some of the steam will condense. The application of this fact to boiler conditions is as follows:

Fig. 1 represents a "closed vessel," the steam pressure being constant, at 140 lb. per sq.in., for example, the initial water level being at B. Should the water level be raised to E, the steam originally in the space B-E will be condensed.

Fig. 2 represents a boiler supplying steam to a reciprocating engine, the initial water level again being at B. Now at a given point of the cycle there will be a definite quantity of steam between the two sections S-S and L-L (or M-M). Should the water level be raised from B to E, the pressure being constant, the engine will continue to take the steam at the same rate and the conditions at any given section will be the same as at the beginning. Consequently, the same amount of steam has left the boiler as would have gone out had the water level not been raised. The total amount of water supplied to the boiler in a given time will therefore be equal to that supplied the engine plus the amount pumped into the equal "closed" vessel of Fig. 1, or equal to the steam supplied the engine (from constant water level B) plus the weight of water in volume E-B, minus the steam condensed in space E-B.

An example will help to make the discussion clear:

Let it be assumed, for instance, that the total water pumped into the boiler in a 10-hour test is 40,000 lb.; that the water level is one inch higher at the end of the test than at the beginning; that the boiler pressure is 115 lb. per sq.in. at the beginning and 140 at the end; that the average pressure is 130 lb. absolute; that each inch of difference of level represents a volume of 4 cu.ft.; that the feed-water temperature is 180 deg. F.; and that the quality of steam is 99.5 per cent.: to find the total equivalent evaporation.

Using the method represented in equation (4), which amounts to the same thing as a combination of (1) and (2), we find:

Total heat in 1 lb. steam above feed temperature at pressure of 130 and quality of 0.995, $H_a = 318.6 + 0.995 \times 872.3 - 147.88 = 1040$.

Specific weight of water at 115 lb. = 56 lb. per cu.ft.

Specific weight of water at 140 lb. = 55.4 lb. per cu.ft.

Specific weight of water at 115 lb. = 0.258 lb. per cu.ft.

Specific weight of water at 140 lb. = 0.31 lb. per cu.ft.

Let

W_1 = Total weight of water in the boiler at beginning of test;

W_2 = Total weight of water in the boiler at end of test;

V_1 = Total volume in cubic feet occupied by W_1;

V_2 = Total volume in cubic feet occupied by W_2

w_1 and w_2 = Corresponding specific weights of water and w_3 and w_4 of saturated steam (dry).

Since w_1 and w_2 are usually approximately equal, and likewise w_3 *and* w_4, the following expression will give results sufficiently close for that portion of the water pumped in which is not evaporated and each pound of which received an amount of heat equal to the difference between the heats of the liquid at boiler and feed temperature:

$$(V_2 - V_1)\frac{w_2 + w_1}{2} - (V_2 - V_1)\frac{w_3 + w_4}{2}$$

In accordance with this method, therefore, the correction of feed water for inequality of water levels will be $4\frac{56 + 55.4}{2} - 4\frac{0.258 + 0.31}{2} = 222.8 - 1.1 =$ 221.7 lb.

According to a strict interpretation of the code the total equivalent evaporation is $\frac{(40{,}000 - 222.8)\ 1040}{970.4}$ = 42,630.

In this expression, however, no account has been taken of the heat absorbed by the water above the temperature of the feed, which amount must be added; and

no account of the 1.1 lb. of steam (condensed) multiplied by the latent heat of vaporization at 140 lb. pressure, 867.6, which amount is to be subtracted.

The total heat absorbed by the boiler will be $(40{,}000 - 221.7) \times 1040 + 221.7\ (327.4 - 147.88) - 1.1 \times 867.6$ and the corresponding equivalent evaporation, that amount divided by 970.4, which gives a value of 42,670.

While there results only a small difference of equivalent evaporation with a correspondingly small percentage of error (about 0.1 of 1 per cent.), the amount seems well worth considering, especially in view of the fact that the calculations are simple. If the difference in water levels were 8 inches, the error would be nearly 1 per cent. by the old method. Every possible error should be eliminated in determinations of this kind, especially when useless refinement will not be entailed.

If the water level at the end were one inch lower than at the beginning, the total heat supplied would be $40{,}000 \times 1040 + 222.8 \times 867.6$; and not $(40{,}000 + 222.8) \times 1040$, the value obtained by the old methods, which gives a value about 0.1 of 1 per cent. too large for a difference of level of one inch.

It would therefore seem advisable to define equivalent evaporation as the total heat absorbed by the boiler in B.t.u. divided by 970.4, and to abolish the term factor of evaporation, because it is seldom that the water levels are the same at the end as at the beginning of a test.

Some Refrigerating Plant Experiences

By Roland L. Tullis

The average steam engineer seems to consider refrigeration as an art in itself and is disinclined to bother his head about the matter. This is a grave mistake, for no steam engineer knows but that he may some day be called to operate a refrigerating plant. Many a competent steam engineer has been compelled to turn down an offer of a better position simply because he was unacquainted with the operation of a refrigerating unit that was a part of the plant.

I once worked with the chief engineer of a large hotel that was buying ice and refrigeration from a central ice plant that was distributing refrigeration through a system of underground piping to a number of hotels in the vicinity. One day the agent of an ice-machine company succeeded in convincing the hotel manager that a considerable sum of money could be saved by installing one of his machines. The manager was impressed by the agent's talk and the data with which the latter backed up his claims, but when he called the chief engineer into consultation he almost had a fight on his hands. The chief didn't want any ice machine. He complained that it would only cause a lot of extra trouble and work for the operating force. He was skeptical. He didn't believe the agent's figures, although he frankly admitted that he knew nothing of the subject. He was perfectly satisfied with the present refrigeration system and its cost. He was a steam engineer of the old school, and he didn't want anything to do with an ice machine.

If the real reasons for the chief's opposition were known, he was simply afraid of an ice machine—afraid he couldn't operate it. However, the manager was quick to surmise about what was the cause of the chief's opposition on the subject. He went right ahead and ordered the machine installed and politely informed the chief that he would have to study up on the subject a little and learn to operate the machine, or he would be compelled to employ a man who was either willing to learn or already possessed the required knowledge. The chief received the manager's ultimatum as a man should. In a few months the machine was installed and running along smoothly. The machine lived up to the agent's promises and saved the hotel company quite a sum of money.

I once took charge of the engine room of a large hotel, the equipment of which included a 35-ton refrigerating machine. The compressor was of the horizontal, double-acting, steam-driven type. You could smell ammonia before you got inside the engine room. I asked the operating engineer about the cause of the leakage. He explained that there had always been a small leak around the piston rod on the compressor, regardless of the fact that they packed it about every ten days. He went on to explain that it gave off a strong odor, but it really did not amount to much as long as you could not see the ammonia coming out. He said that it had been that way as long as he had been on the job, about a year and a half. After I took charge of the plant, I discovered that the piston rod on the compressor was out of line about a sixteenth of an inch and was badly scored, consequently it was impossible to pack it so that it would hold for any length of time.

The ammonia condensers were situated on the main floor of the building near the laundry plant. The laundry foreman complained that the odor of the ammonia was so strong at times that it would drive the employees out of the laundry. The ammonia condensers were of the double-pipe coil type, fitted together with rubber gaskets. Most of the gaskets were in poor condition and leaking badly, especially when the high pressure on the machine rose a little above normal.

The operating engineer explained that they had been running the machine twenty-four hours a day, and that it would hardly supply the required amount of refrigeration. He complained that the capacity of the machine was insufficient for the work that was required of it. However, when I examined the ammonia receiver I could find no indications of ammonia in the glass. I diplomatically questioned him about this and pretended to be a gullible listener, while he explained that he never paid much attention to the ammonia receiver, but always figured that there was plenty of ammonia in the system as long as he could get frost on the pipes. He also complained that he would get too much high pressure on the machine when the ammonia receiver was filled to the proper level. Whenever the expansion valves refused to frost properly, he would close the king valve and pump down to about ten inches of vacuum, then open the valves and start all over again.

After being in charge of the plant a few weeks, I had the ammonia condensers overhauled and all the leaks stopped. The piston rod on the condenser was turned down and properly aligned, and after purging a few thousand cubic feet of air (more or less) out of the system, I had injected a charge of ammonia. The operating engineer was amazed to find that the high pressure stood around 185 lb. with the system full of ammonia. Here is the whole thing in a nutshell. He had been pumping down to ten inches of vacuum, sucking air into the system around the leaky piston rod on the compressor. The air in the system caused the exceedingly high back pressure. While he imagined that the high back pressure signified that there was plenty of ammonia in the system, he was simply using good steam to churn air and gas around through the system.

I found that, when this installation was properly operated, it could be shut down nearly twelve hours a day. The temperatures were lower than ever before, and the records of operation show an almost unbelievable saving in ammonia.

EDITORIALS

Progress in the Power Field

LOOKING back over the preceding year to review progress in the field has been the practice in *Power* for some time. As is usual at this period, our summary may be found on the leading pages of this issue. For the year no great advance can be recorded. It was more a period of crystallization in which the results from previous effort were considered as a guide for future development. This is particularly true of the turbine field, in which limits of speed and capacity of single-shaft units were given much attention. To improve efficiency the trend is toward higher pressures and less superheat. Disturbances in the industrial field from high prices, the expectation of a decided drop which did not materialize and the demands of radical labor followed by a heavy rush of orders for all kinds of standard power-plant equipment, excluded much of the pioneer work that might have been expected.

In all kinds of labor-saving apparatus for the plant and instruments to conserve costly fuel, there was great activity. In stokers of both the underfeed and chain-grate types there has been progress. To the latter the application of forced draft for burning bituminous coal received much attention, as did the alternate method of burning more coal by increasing the grate area and speeding up the stoker. Improved power dump grates and clinker grinders, sectionalizing of the stoker drive to make more feasible a uniform fuel bed on wide stokers and the development of various methods of drive to accelerate or retard the feed of the coal show the advance in the underfeed stoker.

High-priced coal and the recent shortage has brought about greater use of inferior fuels, more intensive investigation of the possibilities of powdered coal, low-temperature distillation and colloidal fuel, more general use of water power and a great turning to oil, particularly along the Atlantic Coast. To conserve fuel, the tendencies toward concentration and interconnection are more marked. An indication is the proposed power surveys of Secretary Lane.

Of the numerous power stations made ready for operation during the year the steam plant at Kansas City, with its unique economizer installation, is of exceptional interest. In the water-power field the great Queenstown development in Ontario and the new plant of the Niagara Falls Power Company that is to contain three of the most powerful water turbines in the world are in the limelight. The characteristic, size, has been a feature of the year. The past twelve months has seen the placing in operation of the largest turbo-generator ever built, the delivery of equipment for the world's largest furnace, the construction of the largest electric locomotives, the erection of a giant hoisting engine, the design of transformers larger than any yet made and so on.

During the latter part of the year the demand for steam engines was active, more especially for the economical types such as the uniflow. With the increasing use of oil, engines consuming this fuel are in more general use. Both the two- and four-cycle types are being built, and some of the units manufactured are of exceptional size.

In the refrigerating field the high-speed compressor, synchronous-motor driven, is the latest development. Several units of this type have been installed, and reliable data on economy, upkeep and operation is the question of the hour. Great activity marked the electrical profession, heavy export trade being a feature.

The year has been one of activity for the engineer. Lessons of the war had pointed the way. To raise the standing of the profession it was realized that the services rendered to the country should be continued during times of peace. In other words, the engineer has assumed his true rôle, and to make most effective his services to mankind he is realizing as never before the value of coöperation and unity of action. The movement is country-wide. Just what has been done and what is contemplated is told in the review.

Why Boilers Explode

IN a recent issue of *Power* C. E. Stromeyer, chief engineer of the Manchester, England, Steam Users' Association, commented upon the large number of boiler explosions in the United States as compared with those in other countries. The reason has long been known. Other countries exercise intelligent supervision over the design, construction and operation of boilers, and when one explodes a real investigation is made of the condition, and the responsibility fixed. In the majority of our states one may build a boiler any old way that he pleases, out of any kind of stock he can get, carry any pressure upon it that he has a mind to, and hire anyone who comes along to run it.

To those who are accustomed to expert supervision, and acquainted with its effect, this state of affairs is unbelievable. The inhumanity and economic ruthlessness of permitting a hundred or two of preventable boiler explosions a year, rather than to tolerate "Governmental interference with private property," and to maintain the "let us alone" attitude of "we will do as we please with what is our own. The risk is ours—we will pay the damage if there is any," is appalling. There is a gradual weakening in progress, and now fifteen out of our forty-eight states have provided more or less thorough means for the inspection and control of boilers, and four states and twenty-nine cities have laws providing for the certification of the men into whose charge they are given.

A pertinent example of the result of unsupervised operation is given in this issue. The boiler, the explosion of which is there described, was second-hand, a dozen years old, and had never been inspected, except at the time of its purchase a year ago. After the explosion the stem of the safety valve was found so crooked that it took a blow from a small sledge to move it through the cap in either direction. One would suppose that the men in charge of a boiler, whose lives are menaced by any risk incurred in its operation, would be on their guard against such a condition. But they do not know, and innumerable instances of this kind have no weight with the average legislator against the manufacturing constituent who wants to be let alone, or the lobbying dealer.

Lift the Bushel

A JUST complaint of professionals is that their services are not appreciated, and with equal justice it may be said that the general public is allowed to remain in ignorance of what services the professionals are capable of rendering. Their light has been kept under a bushel. Among men who attain the direction of affairs, ignorance of comprehensiveness of the different branches of engineering is astounding.

Probably not more than five men in every thousand are called upon in a lifetime to make arrangements for building a house, erecting a mill or ordering an important power-plant improvement. Accustomed to satisfy their material wants from stocks of shelf-goods, the first thoughts of a project are directed to finding the builder or dealer who will supply the want, although it may be known from experience that there are times and occasions when the drug clerk is to be superseded by the physician and that a man who is his own lawyer has a fool for a client. But without previous experience the prospective investor in engineering work has little or no conception of the advantages or necessity of guidance by services of trained specialists.

The World War has demonstrated that the material, physical and financial strength of nations depends mainly on technical development. The rapid and efficient preparations that we made for the conflict are commonly attributed to American ingenuity, versatility and initiative, but without the breadth of our technical training we could not have risen to the occasion. The opportunities were presented and the achievements of our technically trained men were no less a surprise to our own people than to the rest of the world. Are we now to return to the piping times of peace without better public knowledge or recognition of engineering services? The technical schools and colleges of the United States annually launch thousands of graduates upon the public, and in the present busiest era of our history in many quarters there is to be seen the same old order of affairs that was responsible for crudeness, obsoleteness, waste of time and extravagance in public and private works, due to the neglect of available technical services.

The public always is right, divinely right, because the public must be taken as we find it. But the apathy of which the scientific schools and societies often complain would be replaced by appreciative recognition of the professions if only the public were informed, not by grandiloquent insinuations that so rarely reach the rank and file of active Americans, but by educational advertising.

If our college professors wish to make their labors of actual material benefit and be in a position to demand instead of begging support like timid clerical mendicants, they would do well not only to prepare their students for the world but also to get to work with a vim to prepare the world for their students.

It is a pretty uphill job for a young graduate, after spending the most important years of his life in training for a useful profession, to be turned loose to create a public demand for his services. That is just what the majority of our young graduate engineers must do, and far too many are forced to seek occupations in which their years of special training are of little or no value. It is as criminal for college faculties to dazzle false prospects before parents and students as to salt a gold mine. While it is true—thanks to special opportunities—that hundreds of graduates occupy remunerative positions and are rendering valuable services, the country does not avail itself of the service of thousands of capable young men from a sheer lack of appreciation that results from abject ignorance of the places they are capable of filling in the industrial world.

Fancy how many men of a hundred, as met on the street, are informed of the province of civil, mechanical, electrical or mining engineers. These occupations should be as well known as those of doctors, dentists or clergymen. If professions are unknown to the public, how can it be expected to extend its patronage? If the colleges would have their work appreciated, let them spend a liberal proportion of their time and means spreading information of the advantages of engineering services at least through the public schools. Engaged in such a propaganda, college faculties will be doing more good for the public, for their students and for themselves than to be employed in original research or reading each others' books.

Good Things Coming

READERS will be glad to learn that *Power,* by combining issues in December, has caught up with its schedule and in the new year the paper will be published regularly once a week as usual. Printing difficulties have not been eliminated entirely, but no undue delay is anticipated. For the new year plans have been formulated to make the paper more useful and readable than ever before; and its scope in the industrial field will be broadened. One of the good things in store for the reader is a comprehensive study course on refrigeration. This will be elementary as the title implies and will cover the subject thoroughly. Principles of operation will be explained in a simple way. There will be articles on the compression and absorption systems and other articles dealing with the various elements of each system, such as the compressor, the condenser and the low-pressure end with reference to direct expansion and brine circulation. The series will alternate with an interesting group of articles on steel-mill power plants, discussing equipment and practice in the boiler and engine rooms and the features of the power drives in the mill. There will be other articles dealing with power requirements in textile mills, articles describing governors for steam turbines, small and large, and many more of equal interest to keep the reader abreast of the times in all branches of the profession.

The steel-mill articles start with this issue, and in the next number the study course on refrigeration will begin. The two series mentioned will supplant the electrical study course which was brought to a close in the last issue of the old year. No alarm need be felt, however, for there is a store of good practical electrical material that will make this department more valuable than ever to the operator in the plant.

That the articles mentioned, and in fact the entire contents of the paper from cover to cover, may be of maximum benefit to our readers and help them on their way toward the top is our one best wish for the new year.

It is announced that an engineer at Middlesborough, England, has succeeded in abstracting commercial alcohol and its derivatives from coke. It is asserted that if the process, which requires the use of gas, is applied to all the coal carbonized in Great Britain, a yield of fifty million gallons of motor spirits will be obtained annually. Prohibition papers please copy!

German miners have volunteered to introduce a seventh shift in the week's schedule in order to increase the output of coal. American miners, or rather miners of American coal, have —— Oh, well!

CORRESPONDENCE

Superheated Steam—Why Not?

The statements of the editorial, "Superheated Steam —Why Not?" in a recent issue of *Power,* apparently were not entirely clear, inasmuch as there seems to have been a misinterpretation on the part of Robert W. Wyld in his letter on page 475 of the Sept. 16 issue. The editorial states that one superheater manufacturer has found that from 200 to 250 deg. superheat can safely and satisfactorily be employed with successful lubrication and without material change in the metal used in the cylinders, valves, fittings and piping.

This statement is most assuredly correct. There are many engines that can and do use highly superheated steam, and it is my belief that superheated steam at a temperature as high as practical conditions will permit should always be employed where steam engines are used. No one at the present time would criticize the use of highly superheated steam in turbines, and there are many instances where piston-valve and poppet-valve reciprocating engines are operating with superheated steam of 200 to 250 deg., and these engines are showing a very high economy.

The use of 75 to 100 deg. of superheat in connection with Corliss-valve engines, as pointed out by Mr. Wyld, is certainly conservative, as 100 to 125 deg. not only would be within the limits of safety, but would have the advantage of increased economy due to the high superheat.

As to the use of high degrees of superheat in high-pressure cylinders of marine engines having slide valves, I know of a number of ships that are operating with a superheat of 200 deg. These installations are highly satisfactory in every respect.

While, of course, I am not entirely sure of the company that is credited with having 18,000,000 hp. of superheater installations, I am rather of the opinion that it is possible Mr. Wyld may have had in mind a company that has 80,000,000 hp. of superheater installations in operation. The 80,000,000 hp. referred to is based on the policy of highly superheated steam and designed to produce a degree of superheat adapted to each individual installation. R. A. HANNING.

Yonkers, N. Y.

Using Compression Grease Cup as Wick-Feed Oiler

How an ordinary pressed-steel or brass screw grease cup may be made into a wick-feed oiler similar to the type used on small electric motors is shown in Fig. 1. This has the advantage of a larger oil container than is usually supplied. The base should be drilled out smoothly, if there are any burrs present, and a round felt wick cut to fit the hole snugly but so that it will move freely. A tapered spring is made of brass spring wire with a large-diameter base to fit the cap of the grease cup. This is attached to the wick as shown in Fig. 2. To use as an underfeed oiler, it is only necessary to adjust the wick and spring so that the former will project about a quarter of an inch from the nipple when the whole cup is removed from the bearing, filled with oil and screwed into place.

To use as an overfeed oiler, the cup should be packed with waste and the wick used without a spring, adjusting its pressure on the bearing by screwing down on the cup. The waste will retain the oil in this case, provided the cup threads make a fairly good fit on the base; if too loose, the threads on both cup and base may be coated with shellac and this allowed to become hard before screwing together. H. H. PARKER.

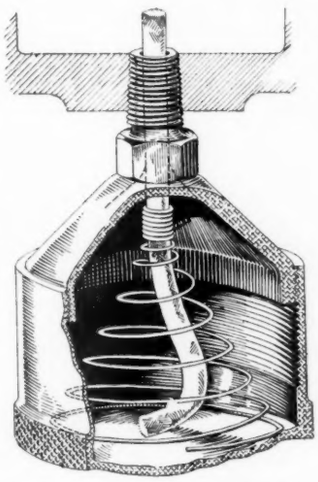


FIG. 1. WICK FEED OILER MADE FROM GREASE CUP

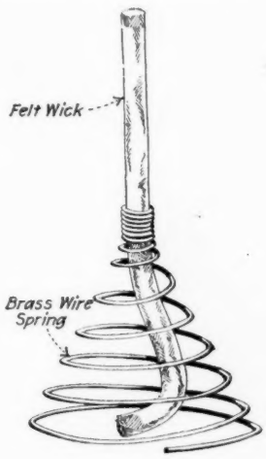


FIG. 2. METHOD OF JOINING SPRING AND WICK

Oakland, Calif.

Smokeless Chimneys Not Conclusive Proof of Furnace Economy

My attention has been called to a letter by W. E. Porter, Chief of Bureau of Smoke Regulations, Pittsburgh, relating to an article appearing under "Inquiries of General Interest," entitled "Smokeless Chimney Not Conclusive Proof of Furnace Economy." Naturally, the smokelessness of a stack appeals to Mr. Porter in his professional capacity, but the fact remains that a

smokeless stack is not conclusive proof of furnace economy. In fact, in a coal-burning plant a stack that is smokeless twenty-four hours a day is indicative of excess air beyond the requirements.

The actual loss of unburned combustible in a smoky stack is probably not more than 1 or 2 per cent. of the heat in the coal. The really objectionable features of smoke are, first, the sooting of the surfaces of the boiler tubes and, second, what is commonly known as the smoke nuisance in a community. The first objection is removed by the daily use of soot blowers, mechanical or hand. The second objection is a matter of the health and comfort of the community and is the only logical reason for a smokeless stack in a coal-burning plant. When a stack is smokeless continuously every hour in the day, the loss due to the excess air more than counterbalances the gain of a small percentage of the unburned combustible.

The foregoing remarks apply particularly to industrial plants. In central-station practice and in recent, well-designed industrial plants, sufficient regard has been taken for proper combustion space by high boiler settings and correct furnace design, so that it is possible to have a smokeless stack as well as an economical plant. In the average industrial plant, where the settings are usually low and no particular attention has been paid to furnace design, a smokeless stack usually means an uneconomical plant. Therefore, we can safely say that the combination of a smokeless stack and an economical plant is more a matter of proper design than of operation, although neither can be neglected at the cost of the other.

JAMES T. BEARD, JR., Chief Engineer,
Fuel Engineering Company of New York.

Remedy for Present Valve Setting

With reference to the indicator cards, by S. L. Gilliam, on page 518 of the Sept. 23 issue of *Power*, I believe the head-end steam valve is leaking badly as shown by the expansion curve and high terminal pressure on the card, Fig. 1, and also by the rapid building up of the compression curve to a point equal to the initial pressure before the piston reached the end of its stroke, although the steam valve has no lead.

The card in Fig. 2 shows a much improved expansion curve, due to lengthening the wristplate connection, giving the valve more seal when closed. The head-end steam valve evidently does not seat properly, and the high spots should be dressed off carefully with a fine file. Having seated this valve properly, adjust the radial rods to give the valves the same lap, with the wristplate central; adjust the hook and eccentric rods to give equal travel, each side of central position, to wristplates and rocker-arms; and, finally, set the eccentrics to give the proper lead. This lead may vary from $\frac{1}{32}$ in. to $\frac{1}{4}$ in., depending, principally, upon the speed of the engine, and should be determined by the appearance of the card. With a long range, Corliss gear, where the steam ports are, say, each $\frac{7}{8}$ in. wide, the valve should have approximately $\frac{9}{32}$ in. lap when closed, and be in the center of its travel, having about $\frac{13}{32}$-in. opening, when the wristplate is central. F. P. STODDART.

Regarding the double-eccentric long-range cutoff engine diagrams by S. L. Gilliam, in the Sept. 23 issue of *Power*, I understand that this type of engine requires a steam-port opening of $\frac{9}{16}$ in. with wristplate on center, instead of $\frac{9}{32}$ in. as he has it. Mr. Gilliam states that there is no lead on the head valve, "yet it is open with engine on the center more than it should be," and that, to decrease the port opening, the rod for that valve is lengthened to its limit.

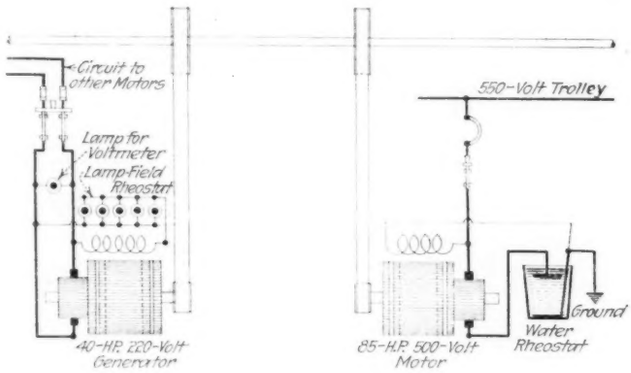
Possibly the fault is too early admission, caused by the steam eccentric being too far ahead of crank. It should be about 30 deg. ahead, or just enough to open the admission valve $\frac{1}{32}$ in. when the crank is on center. Too early admission would cause the engine to pound. E. M. CALKINS.

Johnsonburg, Penn.

Operating a 220-Volt Plant from 500-Volt Service

Fire had destroyed the mill and power plant of a box factory, and I was called in to see what could be done to get things going again. The factory, which was separate from the mill, was unharmed. It was equipped with 220-volt direct-current motors, current being supplied from the power plant. There was no other 220-volt direct-current service to be had, and the only current available was from a 550-volt direct-current street-railway trolley line.

Arrangement was made with the trolley company to use one hundred horsepower from their line, and an 85-hp. 500-volt shunt-wound motor without a starting box was secured. This motor was installed and belted to a lineshaft in the factory. Leaving the belt on the 40-



CONNECTION OF MOTOR AND GENERATOR

hp. 220-volt motor formerly driving the shaft, the latter was driven as a 220-volt generator to supply power to the other small motors and lights about the factory.

As shown in the figure, a set of lamp sockets grouped in parallel was connected in series with the generator's shunt field, for voltage regulation, and a water rheostat was used to start the 85-hp. 500-volt machine. Various-sized lamps were screwed in and out of the socket until the proper voltage was obtained. The switch and fuses used to protect the 40-hp. machine as a motor also served to protect it as a generator. There was no voltage release on the 85-hp. motor since it was started through the water rheostat; therefore it was necessary to keep an attendant near it all the time, as the trolley voltage was very unsteady. We installed a circuit-breaker for the protection of the 500-volt motor and used a pilot lamp temporarily for a voltmeter on the 220-volt generator.

This makeshift operated satisfactorily until the power plant was rebuilt, excepting that occasionally the trolley voltage would fail and shut the plant down. Once the power came on before the attendant got the water rheostat open, and caused the brushes to flash over on the 85-hp. motor, which set on fire an accumulation of sawdust inside the armature where it could not be reached.

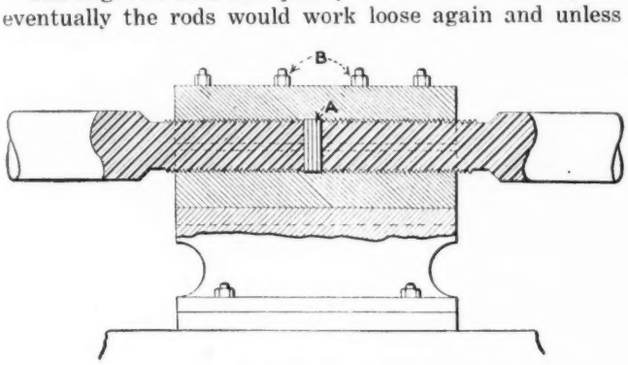
Tampa, Fla. J. C. BUERKE.

Piston-Rod Ends Worked Loose

The piston rods in a large double-acting tandem gas engine kept working loose in the intermediate crosshead. No matter how tightly the cap was pulled down, the rear rod would work loose and turn far enough to one side, to let the tail-rod drain pipe rub the side of the slot in which it worked, to say nothing of spoiling the threads on the rod ends and in the crosshead. The construction of the crosshead was as shown in the cross section of the rod ends and the crosshead.

The usual practice in putting up this crosshead had been to raise the rod ends as high as possible, put the bottom half of the crosshead under, insert enough sheet-iron shims *A* between the rod ends to hold them in the proper position so that the threads in the bottom half of the crosshead would incline to pull the rod ends together when they were let down into place. The top half of the crosshead was then put on and pulled down as tight as possible with the nuts and studs *B*.

The engine would run quietly for some little time, but eventually the rods would work loose again and unless



SECTION THROUGH CROSSHEAD

the engine was taken off the load, something would be ruined in a short time.

It was noticed while taking down the crosshead that the sheet-iron shims would be beaten out flat and although there had been as many put in as possible, they were loose when taken out. From this it was reasoned that there was too much give or spring to these shims and that as soon as the strain came on they flattened out and compressed together enough to allow the rods to come loose again.

The trouble was remedied by making cast-iron shims of the proper thickness to hold the rod ends just far enough apart that the back half of the thread on the rod would ride hard on the front half of the thread in the crosshead; the cap when put on was pulled down as tight as possible. EARL PAGETT.

Cherryvale, Kans.

Freezing of Brine a Puzzle

A recent puzzle in refrigeration proved interesting and might be helpful to engineers who do not as yet know everything about the subject. We have a fifteen-ton ice machine of the ammonia-compressor type. A small pump circulates the brine, a calcium-chloride solution, through the cooling or refrigerating coil and also through some large kitchen iceboxes.

Frequently, during the summer we were bothered with the brine pump coming to a standstill as the result of the brine freezing in the coil passing through the brine tank. Tests were made of the brine and showed a much lower freezing point than that indicated just before the freezing took place. In particular, after dissolving a drum of calcium for two days and testing with salimeter I found the brine should freeze at six above zero. It was a matter of great surprise the next day when it became known that the brine had frozen at twelve above zero.

Not knowing everything about physics, we wondered at this. I theorized that the thermometers might not be recording properly. One thermometer shows the temperature just before entering the refrigerating coil, and the other shows the brine temperature just after leaving the brine coil. Another possibility seemed to be that the calcium might have been adulterated to give the proper salimeter readings without being pure. This may have been fanciful, but it occurred to me nevertheless.

Before I had found out the truth or untruth of these ideas, a more reasonable solution presented itself. The brine tank had been leaking considerably, and it was impracticable to empty it during the hot weather. We allowed the depth of brine to decrease gradually for a few weeks and then filled up again with more water and additional calcium. This took place several times, and finally it occurred to me to connect it with the freezing of the brine at an apparently high temperature above the proper freezing point.

From one to two turns of the refrigerating coil would at times be exposed above the brine level in the tank. Here the freezing of the brine must have taken place. But how was it that the thermometer recorded a temperature six degrees too high for freezing at the departure end of the coil, where normally we find the very lowest temperature attainable in the coil?

The explanation seems as follows: In the refrigerating coil, which is double, consisting of an inside pipe containing the cold expanded ammonia gas and the space between it and the outside pipe containing the moving brine, the temperature of the gas is very low, much lower than the temperature that can be imparted to the moving brine, particularly when the brine pipe is immersed in and, so to speak, warmed by contact with the brine in the tank. But if one or two turns of the coil are not immersed in the brine, the temperature of the brine in these exposed parts of the coil falls very low, not being able to impart any of its low temperature to the surrounding medium—that is to say, not being able to absorb more than a trifle of heat from the air that surrounds the exposed parts of the coil, for air is not a good conductor of heat. Doubtless, before freezing the brine in this part of the coil had been cooled even below its freezing point, but the fact that it was kept in rapid motion by the pump still further reduced it freezing point.

Until the freeze-up became total, the brine of course continued passing through into the immersed part of the coil where it began to absorb heat from the surrounding medium and thereby became warmed so that at the point of departure from the coil its temperature was again practically normal and but little below the entering temperature, say two degrees. In this way the temperature as shown was deceiving concerning the extreme cold which the brine had experienced in one part of the coil. Of course when the general temperature of the brine had reached twelve degrees, the temperature in the exposed part had fallen much below the six degrees required, and brine crystals began to form on the surface of the ammonia, or inner, pipe faster than the moving brine could tear them off. These

crystals gradually built up a solid body of frozen brine or brine-ice until the pump was no longer able to force a passageway. The slower the pumping became the faster the brine froze in that portion of the coil. Frost forming on the outside of the coil also acted as an insulator, further preventing the brine from absorbing heat from the air surrounding the exposed part of the coil.

Buffalo, N. Y. C. A. GOODWIN.

Reverse-Current Relays Installed on Emergency Service

The article entitled "Reverse-Current Relays—Principles of Operation," by Victor H. Todd, published in *Power*, July 15, 1919, is both interesting and instructive and should prove valuable to many engineers, whose plants would be benefited by the installation of this simple but effective protective device.

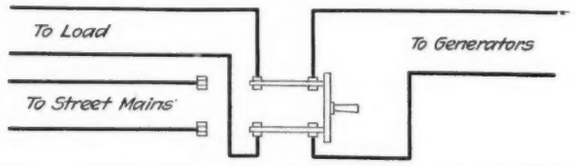


FIG. 1. EMERGENCY-SERVICE SWITCH CONNECTIONS

There is one application of this apparatus, however, not mentioned in the article, and that is its use in an isolated plant in connection with a service switch from the central station. The usual method of installation is to use a double-throw switch, connecting the electrical load to the blades, the plant busbars to one set of clips and the central-station supply to the other, as in Fig. 1. This is not altogether satisfactory, as it is necessary to disconnect the load in most cases before the double-throw switch can be operated.

About a year ago, when many plants, because of labor and coal conditions, were contracting for breakdown service with their local central stations, the plant I am connected with did likewise. However, it was deemed desirable to avoid the installation of the usual double-throw switch if possible. The usual practice when shifting the load from one generator to another is to parallel the machine so as to cause no interruption to the service. It therefore seemed practicable to do the same thing when changing to the outside current or back again; namely, to parallel the street service and the generators and thus avoid a service interruption. In the course of our investigation a representative of the Fire Underwriters was called in, who informed us that to comply with their regulations we would have to install a double-throw switch, as is usually done, or equip the circuit-breaker of our generators with reverse-current relays. In view of this ruling it was decided to install a reverse-current relay on the main circuit-breaker of each generator, as well as on the central-station service circuit-breaker. The outside current would then be connected to the plant busbars through a circuit-breaker, and shifting the load from the generators to the street supply or vice versa would be no different from changing from one generator to another.

The reverse-current relays would prevent the plant from supplying power to the central-station service supply mains and it would prevent the motorizing of our generators by the outside current supply, which I was given to understand was the underwriters' main reason for insisting on either reverse-current relays on the circuit-breakers or a double-throw switch. Fig. 2 gives a schematic diagram of connection, as we had intended for using the reverse-current relays in connection with the generators and service circuit-breaker. However, owing to the press of war work it was found impossible to get relays applied to the circuit-breaker by the manufacturers in a reasonable time, so the project was abandoned.

By equipping each generator's circuit-breaker, as well as the one on the outside-service mains, with its individual reverse-current relay, any opposition to connecting the street service directly to the busbars is eliminated. As the central station is mostly interested in preventing a reversal of current in the power leads they install in a building, by installing and maintaining a relay on their own service switch they would be amply protected from trouble originating in the private plant. The benefits to be derived from this type of installation would be favorable to both parties. For example, it would be possible to shift the load quickly to the service main when cleaning fires and eliminate the loss due to carrying an extra boiler on the line for this purpose, as is usually done. Then, in case of plant trouble there need be no hesitancy in shifting the load to the central station, where with the double-throw switch scheme many engineers take a chance because of the service interruptions while changing over. As can readily can be imagined, the more flexible the service connection is the more often it will be used to the mutual advantage of the private plant and the central station.

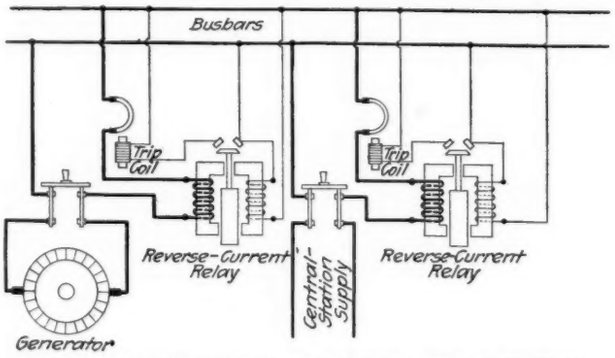


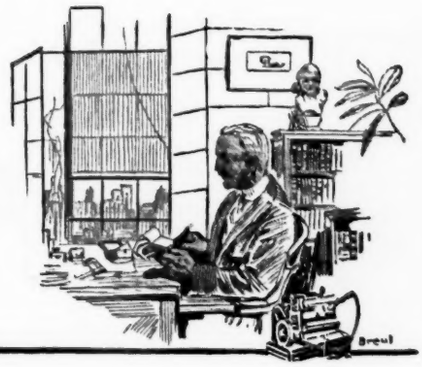
FIG. 2. DIAGRAM OF CONNECTIONS FOR REVERSE-CURRENT RELAYS ON CIRCUIT-BREAKERS

I have never heard of a breakdown service being installed in this way and regret that it was not possible to try it out as contemplated in our plant. However, the idea seemed sound, and the possible benefits are such that I would like to know if such an installation has already been made. Comments on this subject would no doubt prove instructive to readers of *Power*.

New York City. WARREN D. LEWIS.

An employee of a railway company engaged in pumping water into a tank for use by engines pulling interstate trains is entitled to maintain an action under the Federal Employers' Liability Act—for injury received through an unguarded condition of gearing connected with an engine, negligently permitted by the company to exist—on a theory that he was engaged in interstate commerce. (New York Supreme Court, Appellate Division; Kelly vs. Erie Railroad Co., 177 New York Supplement, 278.)

INQUIRIES OF GENERAL INTEREST



Lead for Direct Duplex Pump—Why is not lead given to the steam valve of a direct duplex pump? P. K. D.

The steam valves are without lead in order that the pump may be started at any point of the stroke; and also to enable the piston to be at slow speeds to complete enough of the stroke to obtain reversal of the valve gear for a return stroke.

Relative Pressure for Convex and Concave Heads—What is the relative strength of convex and concave head for a steam drum? B. J. T.

A concave head, or one dished inward so the drum pressure shall come on the convex side, should be used for a maximum working pressure of only 60 per cent. of that allowed for a head of the same dimensions with the pressure on the concave side.

Reduction of Thick Plates at Girth Joints—Why is it necessary to plane or mill down the thickness of plate at the top of the circumferential joints of return-tubular boiler sheets when the main plate thickness exceeds ½ in? J. S. F.

Where exposed to the fire or products of combustion, the plate is to be reduced to one-half thickness to obtain thin enough metal and short enough rivets to prevent burning of the material from not being kept cool by the water of the boiler.

Ammonia Coil for Cooling Water—What length of pipe coil in which there is circulation of zero ammonia should be employed for cooling 200 gal. of water per hour from a temperature of 80 deg. F. to 35 deg. F.? W. E. U.

The mean temperature of the water would be $(80 + 35) \div 2 = 57.5$ deg. F. From data of tests under similar conditions, it is estimated that there would be transfer of heat through an iron pipe coil at the rate of 105 B.t.u. per hour per square foot of pipe surface, for each degree difference of mean temperature. Hence one square foot of pipe surface would absorb $105 \times 57.5 = 6037.5$ B.t.u. per hour. In cooling the water from 80 to 35 deg. F., each pound of water would part with 45 B.t.u. and for cooling 200 gal., or about 1666 lb., of water per hour, there would need to be absorption of $1666 \times 45 = 74{,}970$ B.t.u. per hr., requiring $74{,}970 \div 6{,}037.5 = 12.4$ sq.ft. of coil surface, or $12.4 \times 2.3 = 28.5$ lin. ft. of 1¼-in. pipe. This is without any allowance for gain or loss of heat due to the temperature of surrounding atmosphere, extent of tank surface or character of insulating material employed.

Compression Valves on Steam End of Pump—How are the compression valves arranged on a pump that is equipped with them? F. C.

A compression valve at each end of the steam cylinder of a pump is so arranged as to vary the size of a small opening in the partition between the steam passage and the exhaust passage. The piston covers the exhaust passage before the stroke has been completed, thus compressing any exhaust steam then remaining in the cylinder and steam passage at the end of the cylinder, and if the piston cushions too heavily, the compression valve is adjusted to permit escape of excessively compressed exhaust in the end of the cylinder, to the exhaust passage, by way of the steam passage.

Click in Engine With a Particular Pressure—What may be the cause of a clicking noise that seems to be in the crankshaft of a large Corliss engine whenever the steam pressure drops to 85 lb.? This has taken place for many months, apparently without change, and after careful inspection of the shaft, flywheel, crank and crankpin there is no apparent cause for noise from movement of those parts of the engine. P. F. C.

The cause of clicking or knock in an engine is frequently difficult to locate on account of transmission of sound from one part of the engine to another. If the noise occurs only with change to a particular initial pressure, regardless of load, it is most likely due to play of a piston packing ring or of the bull ring. In any event, the cause of a click, knock or rattling that is coincidental with certain pressure conditions should be sought for in the cylinder of the engine.

Return Trap Connections—We are installing some machinery that requires a supply of live steam and will have return traps for returning the condensation to the boiler, carrying 85 lb. pressure. One of the machines is to be supplied with steam reduced to the pressure of 30 lb. gage. How should the returns and trap be arranged and connected? F. K.

All returns connected to a trap or receiver should be at the same pressure; otherwise those of higher pressure will prevent the trap from simultaneously receiving returns of lower pressure. Systems of returns that are at different pressures will require separate traps. The return pipes should be sloped so they will be drained perfectly clear of condensation and discharged by gravity to the trap with the trap placed four feet or more above the water line of the boiler. It is well to place an automatic air valve on the return line near the trap and also provide a pet-cock for testing whether the returns are being emptied. When the trap becomes filled with return water, the mechanism automatically admits live steam from the boiler for siphoning the water into the boiler, but cannot do so unless the receiver is elevated sufficiently for obtaining the necessary head of discharge water for overcoming friction of the trap discharge pipe and fittings. There should be a separate return connection to the boiler, with check valve or connection so arranged that the discharge will not be affected by pulsations of a boiler-feed pump. The inlets and outlets for admission and discharge of return water, and for admission of live steam and discharge of displacing steam, are usually described in directions issued by the manufacturer or are indicated on the trap. If the water inlet of the trap is not provided with a check valve, one should be placed in the return line near the trap. Most return traps are provided with a small outlet for discharge of the displacement steam. This should be provided with a stop valve and pipe connection for discharging the steam in the boiler ashpit or at some other point where a small quantity of air steam or water discharge from the trap would not be objectionable.

The Hvid Engine and Its Relation to the Fuel Problem

By E. C. BLAKELY

This paper describes in detail the arrangement and operation of an internal-combustion engine which, the author claims, has all the advantages and none of the disadvantages of the Diesel type. It can be made in small sizes and has no electric or other ignition devices to cause complications. Curves from actual tests are given to show its fuel economy as compared to gasoline and kerosene engine of the same size. Curves showing the results of heat balance tests are also given.

MUCH has been written and said during the last two or three years on the subject of using kerosene as fuel in conventional gasoline engines of both low- and high-speed types. While undoubtedly much has been learned concerning the characteristics of kerosene under such conditions, the burning of kerosene in gasoline engines has not been accomplished with complete success. By complete success is meant starting the engine on kerosene in atmospheric temperatures approximating zero degrees Fahrenheit and below, without preliminary heating of any sort, and burning kerosene so as to eliminate troublesome carbonization and complicated accessory apparatus, and obtaining high economy.

Kerosene and gasoline are widely different substances chemically, having nothing in common but the base from which they are derived. Their initial boiling points are wide apart, that of commercial gasoline being about 100 deg. F., while that of kerosene is about 330 deg. F. Under these conditions a carburetor designed for vaporizing gasoline cannot be expected to vaporize kerosene. The best it can do is to atomize it.

In order to vaporize, as well as to prevent precipitation or condensation of the atomized kerosene in the combustion chamber, it is necessary to heat the charge; and since the power output of the engine depends on the amount of charge taken in and burned during each cycle, it is clear that the more the charge is heated the less mixture we can get into the cylinder and the less power we can obtain. This forces us to a compromise between two conflicting conditions—the maintenance of the incoming charge at the lowest possible temperature that will vaporize the kerosene, and the prevention of precipitation in the combustion chamber. This compromise is especially difficult in the case of an engine running at varying speeds and loads.

In order to obtain maximum power from the engine, we must have maximum mean effective pressure; and since mean effective pressure depends largely upon compression pressure, we must use the highest compression pressure possible. In order to prevent so-called preignition when burning kerosene, we are forced to a relatively low compression pressure, which lowers the mean effective pressure and therefore the power output.

There have been built in the last ten years numerous engines capable of running consistently on the various crude and fuel oils, as for instance Diesel and the so-called semi-Diesel engine, hot-bulb and hot-surface ignition engines. These, however, have been used mainly in marine work and in relatively large units. The latter types have the disadvantage of requiring external preheating before they can be started, and the torches used for this purpose are a source of constant danger. Electric preheating has been tried, but with little success.

There is an engine, however, that has all the advantages of the aforementioned types and, we think, none of the disadvantages. This is the Hvid engine. It can be started cold on any liquid fuel that will flow through a pipe. It has no complicated air-compressure system for injecting the fuel, no electrical devices, no carburetor or mixer, no hot-bulb or torches, and runs with a fuel economy on a par with that of the Diesel engine. The Hvid engine can be, and is being, produced in units as small as 1½ hp., and so economically as to be able to compete with gasoline engines of the same size.

Briefly enumerated, the chief advantages of the Hvid engine are: Mechanical simplicity, low fuel consumption at all loads, ability to start and run on any oil that will flow, low water-jacket losses, no lubricating difficulties, constant compression, remarkable torque characteristics, absence of all electrical devices, hot-bulbs and torches for ignition purposes, absence of all carbureting mechanism, and finally, no carbon troubles. The Hvid engine is of the conventional four-stroke-cycle type embodying the usual inlet and exhaust valves, which open and close as in any four-stroke-cycle engine. The compression pressure is carried to between 425 and 475 lb. to the square inch, which heats the compressed air between 900 and 1000 deg. F. In the cylinder head there is a fuel-admission valve terminating in a small steel cup, by means of which a preliminary explosion is made to force the fuel into the combustion space. Referring to Fig. 1, the Hvid cycle is as follows: During the suction stroke pure air is admitted to the cylinder through the intake valve *A*. Fuel valve *B* is opened at the same time with intake valve *A* and some fuel flows into the cup *C* out of the hole *D*, which is uncovered by the opening of valve *B*. The fuel enters cup *C* partly by gravity

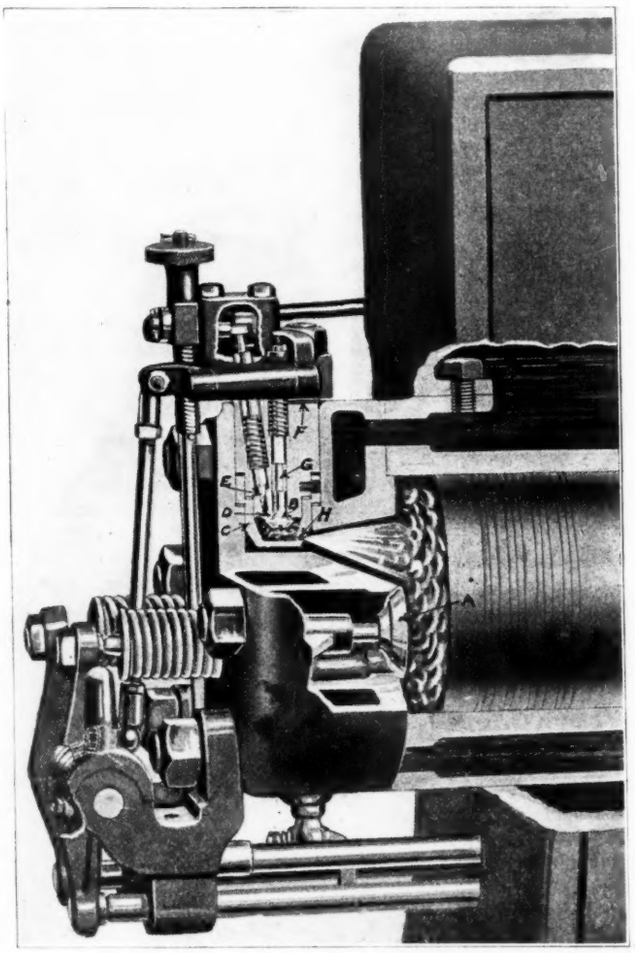


FIG. 1. SECTION THROUGH CYLINDER HEAD OF HVID ENGINE

*Abstract of a paper presented to the Annual Meeting of the American Society of Mechanical Engineers, Dec. 2-5, 1919.

and partly by suction. The amount of fuel admitted is controlled by the metering pin *E*, which in turn is controlled by the governor. At the same time that the fuel is being taken into the cup, a small amount of fresh air has also gone through an auxiliary air-hole *F*, down past a fluted guide *G* into the cup *C*. At the end of the suction stroke, the fuel valve *B* and the air-intake valve *A* close, valve *B* covering the fuel-admission hole *D*. During the compression stroke all valves are closed and the air admitted to the cylinder on the suction stroke is compressed and its temperature raised. There is now a mass of highly heated air under high pressure in the combustion chamber, and this rushes into the cup *C* through the small holes *H*, near its bottom, until the pressure in the cup is practically equal to the pressure in the combustion chamber. The conditions in the cup are now most favorable to "cracking" the oil, and as it cracks, the lighter and more volatile components are ignited by the high temperature and the resulting high pressure within the cup forces the rest of the oil out into the air in the cylinder. The amount of fuel consumed in the cup per cycle is infinitesimal because there is only a very small amount of air present in the cup to support combustion. As the fuel, in an atomized and vaporous state, comes into contact with the heated air in the combustion space, very rapid combustion takes place and the pressure arising from it drives the piston. As in any four-stroke cycle, the exhaust valve opens and the products of combustion are forced out of the piston on the exhaust stroke.

It is interesting to note the waves in the expansion line of indicator cards taken from these engines. These are typical of all cards taken from Hvid engines and are caused by the introduction of fuel into the combustion chamber in waves. At the moment when the preliminary combustion takes place in the cup, we have in the cup a pressure approximately 800 lb., while in the combustion chamber there is a compression pressure of only about 425 lb. Some fuel is consequently sprayed out of the cup into the combustion chamber by the attempt at pressure equalization. When the fuel comes in contact with the highly heated air in the combustion chamber, the pressure rises in the combustion chamber and falls in the cup until equalized, then

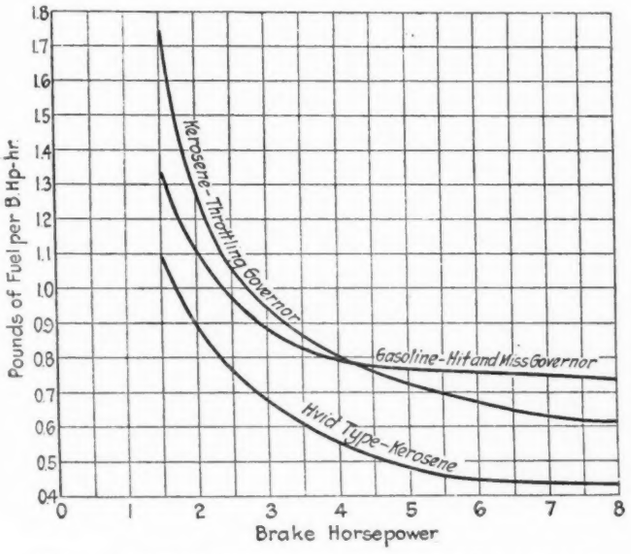


FIG. 2. COMPARATIVE FUEL-CONSUMPTION CURVES

no more fuel can get out of the cup until the piston moves forward and the pressure of the cylinder drops below that in the cup, when more fuel is ejected.

The fuel consumption of small Hvid-type engines is very good, being in general on a par with Diesel engines of large size. In the comparative fuel-consumption curves shown in Fig. 2, the fuel economy of the Hvid engine as compared with two other types of the same size stands out very plainly, particularly at the lower fractional loads. The "hit-and-miss" gasoline-engine test was made by Professor Dickinson, of the University of Illinois, and the throttling governing kerosene-engine test by Mr. MacGregor, of the Hercules Gas Engine Co., under the supervision of Government experts. The Hvid-engine test was made by the writer under the supervision of Professor Roesch, of the Armour Institute. The engine used in each case was a 5¾-in. by 9-in., running 450 r.p.m. and rated at 8 horsepower.

A small 3-in. by 4½-in. Hvid engine was designed to run at 1100 r.p.m., and at first the results to be expected from it were not looked upon with favor because of its high speed. This, however, showed that this engine could be run at a speed as high as 1500 r.p.m. without any appearance of interference with the perfect operation of the Hvid principles. Based on its performance, several engineers connected with the production of Hvid engines raised the normal speed of their engines with very beneficial results. The result of some heat-balance tests is shown in Fig. 3. These tests were made upon a 5¾-in. by 9-in. single-cylinder Hvid engine, which was flexibly

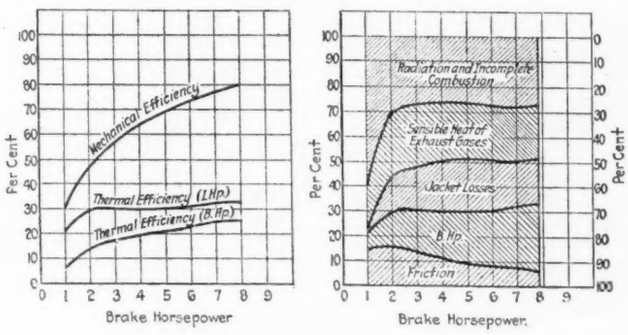


FIG. 3. EFFICIENCY AND HEAT BALANCE CURVES FROM 8-HP. HVID ENGINE

connected with a Sprague electric-cradle dynamometer by means of two universal joints. Arrangements were made for determining the jacket-water loss and the sensible heat in the exhaust gases, the latter by the calorimeter method. The developed and friction horsepower were determined by means of the dynamometer. Indicator cards were taken, but because of the probable errors due to the high pressure involved and the comparatively high speed of the engine, these cards were used merely to study the valve setting and general events of the cycle and not for indicated power measurements. The heat value of the fuel expressed in B.t.u. per pound of kerosene is calculated from the following accepted formula:

$$B.t.u. = 18{,}440 + 40\ (deg.\ B\acute{e} - 10)$$

and is 19,740 B.t.u. for the quality of fuel used in test runs.

The torque characteristics of the Hvid engine are of considerable interest. When a gasoline engine of conventional design is overloaded so that the speed drops below a certain point, its torque drops rapidly, because a certain velocity of air must be maintained through the carburetor to pick up and vaporize the fuel and carry it in the cylinder. In a Hvid engine, however, since the introduction of fuel in the cup and into the cylinder is not dependent upon the velocity of the air taken in, as the speed drops due to overload, more fuel is admitted than at normal speed, because the time element for the introduction of fuel is lengthened. The engine consequently shows remarkable "hanging-on" characteristics. Under these conditions it is very wasteful of fuel without a doubt, but there are certain conditions where this "bulldog" characteristic is desirable even though it be at the expense of fuel economy.

In conclusion the writer says that while the Hvid engine has by no means reached its ultimate state of development, it nevertheless possesses a number of wonderful characteristics which ought to attract many internal-combustion engineers by the possibility they hold out of helping to solve some of our fuel problems.

At hearing by Joint Congressional Commission on Reclassification of Salaries to committee representing Federal employees it was disclosed that a "turnover" in personnel among scientific and technical workers of the Government amounting in some offices to one hundred per cent. a year prevailed.

Steam Boiler and Flywheel Service Bureau Accepts Autogenous Welding

The committee referred to is made up of engineers of all the insurance companies writing steam-boiler insurance in the United States. For the purpose of obtaining uniform practice in the acceptance of autogenous welding the sub-committee reports:

By "autogenous welding" is meant any form of welding by fusion; that is, where the metal of the parts to be joined or added metal used for the purpose is melted and flowed together to form the weld. Such welding is accomplished by the oxyacetylene, hydrogen or other flame processes, or by the electric arc; no distinction is made between any of these processes. The general rule to govern the acceptance of such welds in insured vessels is that prescribed by the Boiler Code of the American Society of Mechanical Engineers, Par. 186, as follows:

> Autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the Code, and where the safety of the structure is not dependent upon the strength of the welds.

The following illustrations will serve to point out where such work should be accepted or rejected.

1. Any autogenous weld of reasonable length will be permitted in a stay-bolted surface or one adequately stayed by other means so that should the weld fail, the parts would be held together by the stays. It is necessary for the inspector to use judgment in interpreting the meaning of "reasonable length" as given above, since it may vary in different cases. In the average case it should be not more than three feet. Autogenous welding will not be accepted in unsupported surface.

2. The edges of the inner and outer sheets of vertical firebox boilers or boilers of the locomotive type may be joined by autogenous welding to from the door openings, if the surrounding surfaces are thoroughly stayed. This would also apply to other openings of a similar character in such surfaces.

3. For low-pressure plate-steel boilers operated at a pressure not exceeding 15 lb. per sq.in., or for higher pressures in unfired vessels subjected to water pressure only, rectangular headers may be autogenously welded at the edges if the sheets are properly held together by stays. Autogenous welding of cracks and fractures in cast-iron boilers will not be permitted.

4. Fire cracks in girth seams extending from the edge of the plate to the rivet hole may be autogenously welded provided the cracks are properly prepared by cutting out the metal at the crack in the form of a letter V to permit fusion through the entire thickness of the plates. Similar cracks in girth seams located between the rivet holes may also be autogenously welded, provided the cracks do not extend beyond the edge of the lap of the inner plate. In the latter class of cracks it is advisable to drill a hole not exceeding 3/8 in. in diameter at the end of the crack before the weld is made. Cracks extending from rivet hole to rivet hole on girth seams cannot be welded. Calking edges of girth seams may be built up by autogenous welding where the original section of the metal between rivet holes and calking edge to be built up, averages equivalent to one-fourth the diameter of the rivet hole and the portion of calking edge to be replaced does not exceed 30 in. in length in a girthwise direction. In all repairs to girth seams by autogenous welding the rivets must be removed over the portions to be welded and for a distance of at least 6 in. at each end beyond such portions. After repairs are made the rivet holes should be seamed before the rivets are redriven.

5. Stayed sheets which have corroded to a depth of not more than 40 per cent. of their original thickness, may be reinforced or built-up by autogenous welding. In such cases the stays shall come completely through the reinforcing metal so as to be plainly visible to the inspector.

6. Where tubes enter flat surfaces and the tube sheets have been corroded or where cracks exist between the tube ligaments, autogenous welding may be used to reinforce or repair such defects. The ends of such tubes may be autogenously welded to the tube sheets. The above-mentioned repairs for tube sheets and the welding in of tubes in the sheets are not to be permitted where such sheets form the shell of a drum or boiler, such as in the case of Stirling type of boiler.

7. When external corrosion has reduced the thickness of plate around handholes to not more than 50 per cent. of the original thickness and for a distance not exceeding 2 in. from the edge of the hole, the plate may be built up by autogenous welding.

8. Pipe lines will be accepted where the flanges or other connections have been welded autogenously, provided the work has been performed by a reputable manufacturer and the parts properly annealed before being placed in position. Such welding, when made with the part in place and unannealed, will not be acceptable.

9. Autogenous welded-in patches in the shell of a boiler will not be acceptable regardless of the size of such patches. Autogenous welding of cracks in the shell of a boiler—except those specified in Par. 4—regardless of the direction in which they may lie, will not be permitted unless such welding is only for the purpose of securing tightness and the stresses on the parts is fully cared for by properly riveted-on patches or straps placed over the weld. The plates at the ends of joints may be welded together for tightness, provided the straps or other construction is ample to care for the stresses on the parts so welded.

10. Re-ending or piecing of tubes for either fire-tube or water-tube boilers by the autogenous process will not be permitted.

Electric Undertakings in Japan

The accompanying tables and charts are arranged from data given in the Statistical Report of Electric Undertakings in Japan, compiled by the Director General of Electric Exploitations, Department of Communications, Tokyo, Japan. This report is dated June, 1919, and is a summary of the chief statistics showing the condition of existing electric undertakings at the end of 1917.

Table I gives the number of undertakings by Kind of Primary Power for various classes of plants, while Table II gives

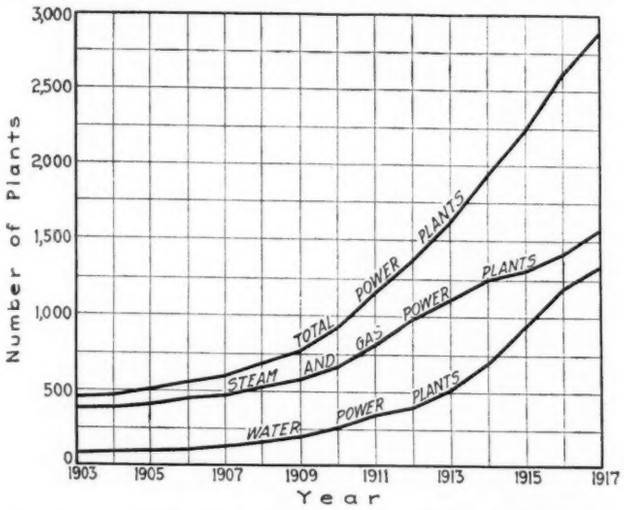


FIG. 1. GROWTH IN NUMBER OF ELECTRIC UNDERTAKTAKINGS IN JAPAN FROM 1903 TO 1917

the kilowatt capacities under the same classifications. It is interesting to note the relative number and capacity of the water-power plants as compared with the steam and gas plants.

The charts show the growth of the industry since 1903. Fig. 1 gives the number of plants and Fig. 2 their capacity at the end of each year from 1903 to 1917. The values in Fig. 2 include the reserve capacities, so they are somewhat higher at the end of 1917 than those given in Table II.

The report further classifies the plants as to voltage. There were 1865 plants having 51,170 kw. capacity carrying "low" voltage or less than 600 volts d.c. or 300 volts a.c.; 843 plants with 211,600 kw. carrying "high" voltage or higher than "low" voltage and lower than 3500 volts, and 183 plants with 490,000 ky. capacity carrying "extra high" voltage of more than 3500.

There were 37,120 miles of electric line using 132,794 miles of wire. The electric railways covered 434 miles and used 4539 cars.

Electric-light consumers numbered 4,243,000, or 41.2 per cent. of the number of households. They used over ten million lamps having a total equivalent electric power of 173,000 kw. Power consumers, including isolated plant users as well as public-service users, used 85,860 motors requiring practically 600,000 kw. Other electric appliances required 100,000 kw. additional.

The average price to small consumers for electric light was 9.9c per kw.-hr. from water-power plants and 11c from steam

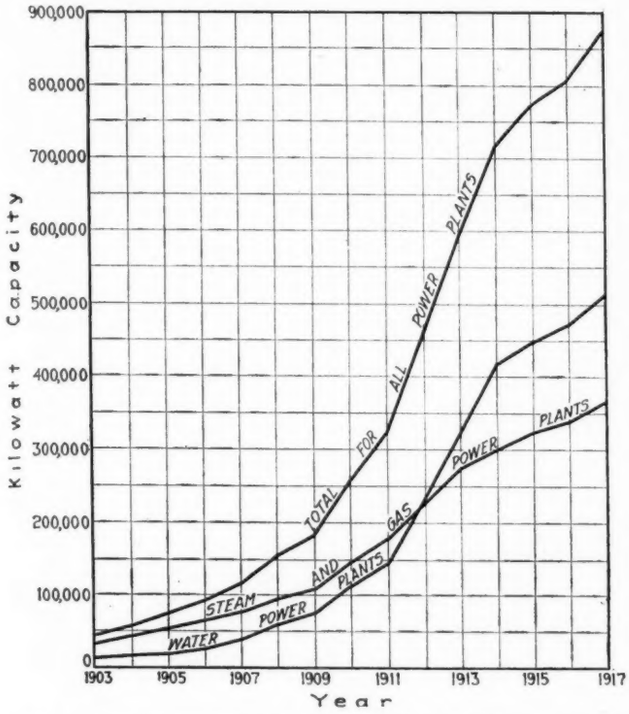


FIG. 2. GROWTH IN CAPACITY OF ELECTRIC UNDERINGS IN JAPAN FROM 1903 TO 1917

and gas plants. The corresponding average power rates were 3.15c and 4.46c respectively. Including traction plants there was a total paid-up capital of $180,650,000 in public-service plants on which amount a profit of 10.7 per cent. was earned.

TABLE I. NUMBER OF UNDERTAKINGS USING WATER, STEAM AND GAS POWER

Undertakings	Water	Steam	Gas	Total
Electric supply	360	44	93	497
Electric traction	23	5	..	28
Electric supply and traction	32	15	1	48
Isolated plants	869	786	533	2188
Official plants	47	73	10	130
Total	1331	923	637	2891

TABLE II. KILOWATT CAPACITY FROM WATER, STEAM AND GAS POWER

Undertakings	Water	Steam	Gas	Total
Electric supply	338,682	43,675	5,976	388,333
Electric traction	180	1,000	....	1,180
Electric supply and traction	71,624	68,809	655	141,088
Isolated plants	56,357	123,782	15,567	195,706
Official plants	400	20,630	5,665	26,695
Total	467,243	257,896	27,863	753,002

National Fuel-Inspection System

A fuel-inspection system that will give the consumer and the producer of coal accurate information concerning the commodity is proposed by the Secretary of the Interior. In an estimate recently transmitted to Congress, he asks for an appropriation of $725,000. The system is to be administered by the Bureau of Mines. The work is to be under the immediate direction of a chief coal inspector, who is to receive a salary of $5000. Among the other positions which are specified in the estimate are: Assistant chief coal inspector, $4000; 6 district coal inspectors, $4000; 100 field coal inspectors, $2400. In explaining the need for the appropriation, Secretary Lane said:

Inspection, sampling analysis, and certification of coal should be made by the Government. This practice is followed in other commodities and would be a benefit to the producers of clean coal, the consumers, and to the interest of foreign commerce. This will assure the consumer the grade of coal which he pays for, protect the interest of those preparing clean coal, without discouraging the mining of poorer grades of coal and should exert an influence toward good coal preparation.

This coal inspection system proposed by the Bureau of Mines contemplates as a salient feature advice as to the quality of coal shipped. It is proposed that each mining company set its own standard of quality, consistent with the particular vein preparation, and the market which the business affords, and that the Government shall publish such standard and certify as to whether such standard is being maintained by the mining companies. There is not contemplated a certification as to each and every shipment, but the system does provide for the accurate sampling of full carload lots and for the inspection and sampling at irregular intervals of a sufficient number of cars of coal to indicate whether the declared standard of the mining company is being maintained. The coal-mining companies would coöperate and enter the system and be privileged to advertise that their product was from a mine whose standard of preparation was certified by the Government. In case the coal shipment was below the standard, the mine owner would be promptly advised of the fact, and where possible, the consumer would receive a notice to the same effect. If the coal continues to fall below the standard, it would be removed from the certified list established by the Government and the mine would be required to declare a new and different standard which its product could meet.

The Ohio Board of Boiler Rules, at its last regular meeting held at Columbus, Ohio, Feb. 12-13, 1919, unanimously adopted the following resolutions: Whereas, Since the passage of the Ohio Boiler Inspection Law by an Act of Legislature, May 31, 1911, miniature boilers of less than two horsepower have appeared in large numbers; and Whereas, These miniature boilers are used in connection with tire vulcanizers, clothes presses, matrix tables, etc.; and Whereas, It is the opinion of this board that the purpose of the boiler inspection law is to apply only to steam boilers containing a volume of water sufficient to cause a serious explosion; Therefore, Be It Resolved, That Section 18 (1058-23 Ohio Code) be interpreted to exclude from shop inspection and stamping, miniature boilers referred to in Part 2, Sec. 4, p. 43, 1918 edition Ohio Boiler Rules.

SWAT THE WASTER

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$8.20@$8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	3.60@ 3.80
Rice	2.30@ 2.50
Barley	1.25

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$3.85@$3.35	$3.15@$3.60
F.o.b. Philadelphia, gross tons	5.05@ 5.60	5.35@ 5.90
F.o.b. New York, gross tons	5.40@ 5.95	5.75@ 6.25
Alongside Boston (water coal), gross tons	7.00@ 7.75	7.60@ 8.00

Pocahontas and New River are practically off the market for coastwise shipment, but are quoted at $6.25@$7.00.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

Anthracite

	Company Coal
Broken	$7.80@$8.25
Egg	8.20@ 8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	5.15
Rice	4.50
Barley	4.85
Boiler	4.85

Bituminous

	Spot
South Fork (best)	$3.25@$3.50
Cambria (best)	3.00@ 3.25
Cambria (ordinary)	2.60@ 2.90
Clearfield (best)	3.00@ 3.25
Clearfield (ordinary)	2.60@ 2.90
Reynoldsville	2.85@ 2.90
Quemahoning	3.25@ 3.50
Somerset (medium)	3.00@ 3.25
Somerset (poor)	2.50@ 2.75
Western Maryland	2.50@ 2.75
Fairmont	2.25@ 2.50
Latrobe	2.60@ 2.90
Greensburg	2.75@ 3.00
Westmoreland ¾ in.	3.40@ 3.50
Westmoreland run-of-mine	2.75@ 3.00

PHILADELPHIA—Anthracite prices are practically the same as those listed above for New York. Bituminous coal prices vary according to district from which they are mined. For ordinary slack the price is $2.45@$2.55; lump, $3.00@$3.35.

BUFFALO—

Anthracite

	On Cars, Gross Ton	At Curb, Net Ton
Grate	$8.55	$10.80
Egg	8.80	10.65
Stove	9.00	10.85
Chestnut	9.10	10.85
Pea	7.75	9.30
Buckwheat	5.70	7.75

Bituminous

Allegheny Valley	$4.80
Pittsburgh	4.65
No. 8 Lump	4.65
Mine Run	4.80
Slack	4.10
Smokeless	4.60
Pennsylvania Smithing	5.70

CLEVELAND—Prices of coal per net ton delivered in Cleveland are:

Anthracite

Egg	$11.75@$11.90
Chestnut	12.00@ 12.00
Grate	11.75@ 11.90
Stove	11.90@ 12.10

Pocahontas

Mine-run	$7.50

Domestic Bituminous

West Virginia splint	$8.50
No. 8 Pittsburgh	$6.60@ 6.90
Masillon lump	8.25@ 8.50
Coshocton lump	7.15

Steam Coal

No. 6 slack	$5.25@$5.50
No. 8 slack	5.10@ 5.50
Youghiogheny slack	5.25@ 5.50
No. 8 ¾ in.	5.70@ 6.00
No. 6 mine-run	5.25@ 5.50
No. 8 mine-run	5.75

Only coal available is mine-run Pocahontas.

MIDDLE WEST—Chicago quotations, F.o.b. cars at mine:

	Springfield Carterville Williamson Franklin Saline Harrisburg	Fulton Peoria	Grundy La Salle Bureau Will
Lump	$2.55@$2.70	$2.95@$3.10	$3.25@$3.40
Washed	2.75@ 2.90	.....	3.45@ 3.60
Mine Run	2.35@ 2.50	2.75@ 2.90	3.00@ 3.15
Screenings	2.05@ 2.20	2.35@ 2.50	2.75@ 2.90

New Construction

PROPOSED WORK

Mass., Amherst—The Massachusetts Agricultural College will soon award the contract for the construction of a 2 story, 60 x 120 ft. memorial building on the Campus. A steam heating system will be installed in same. Total estimated cost, $150,000. James H. Ritchie, 8 Beacon St., Boston, Arch.

Mass., Brookline (Boston P. O.)—Louis Shapiro, 27 School St., Boston, will build a 2 story, 85 x 270 ft. auto sales building on Commonwealth Ave. A steam heating system will be installed in same. Total estimated cost, $250,000. Work will be done by day labor.

Mass., New Bedford—The City Hospital Commission received lowest bid for the installation of a steam heating system in the proposed hospital, which includes a 3 story, 46 x 175 ft ward, 2½ story, 46 x 180 ft. operating building and a 2 story, 50 x 160 ft. laundry, on Mt. Pleasant St., from the Power Heating & Ventilating Co., 49 Travers St., Boston, $121,750.

Mass., Wakefield—Lee & Hewett, Archs. and Engrs., 1123 Broadway, New York City, will soon award the contract for the construction of a 3 story factory addition for Heywood Bros. & Wakefield Co., Gardner. A steam heating system will be installed in same. Total estimated cost, $150,000.

Conn., Hartford—Bliss, Hill & Steiger are having plans prepared for the construction of a 6 story department store. A steam heating system will be installed in same. Buchman & Kahn, 56 West 45th St., New York City, Archs. and Engrs.

Conn., New Haven—Brown & Von Beren, Archs., Chamber of Commerce Bldg., will soon receive bids for the construction of an 8 story, 80 x 80 ft. store and storage building on Meadow St., for John Kilfeather, Meadow St. A steam heating system will be installed in same. Total estimated cost, $125,000.

Conn., Thomaston—The Seth Thomas Clock Co., c/o Lockwood, Green & Co., Archs. and Engrs., 101 Park Ave., New York City, will soon receive bids for the construction of a 2 story, 60 x 120 ft. and a 4 story, 60 x 120 ft. factory buildings. A steam heating system will be installed in same.

N. Y., Brooklyn—B. W. Dorfman, Arch., 26 Court St., is preparing plans for the construction of a 5 story factory on Grand Ave. and Dean St. A steam heating system will be installed in same. Total estimated cost, $200,000. Owner's name withheld.

N. Y., College Point—The American Hard Rubber Co. is having plans prepared for the construction of a 1 story, 120 x 130 ft. factory addition. A steam heating system will be installed in same. Walter Kidde, 140 Cedar St., New York City, Arch. and Engr.

N. Y., Long Island City—The B. J. Johnson Soap Co., c/o Lockwood, Greene & Co., Archs., 101 Park Ave., New York City, is having plans prepared for the construction of a 4 story warehouse. A steam heating system will be installed in same. Total estimated cost, $250,000.

N. Y., Milbrook—H. Ross, 47 West 34th St., New York City, is having plans prepared for the construction of a group of 1 and 2 story buildings for a sanitarium in Duchess County. A steam heating system will be installed in same. Total estimated cost, $300,000. Alfred Bodker, 62 West 45th St., New York City, Arch. and Engr.

N. Y., Mineola—The Knickerbocker Ice Co., 1480 Broadway, New York City, will soon award the contract for the construction of a 1 story ice plant. Estimated cost, $110,000. W. Mortensen, 209 West 76th St., New York City, Arch. and Engr.

N. Y., New York—The Board of Education, 500 Park Ave., is having plans prepared for the construction of a 5 story, 120 x 195 ft. school on St. Anns Ave. and Hagney Pl. A steam heating system will be installed in same. Total estimated cost, $500,000. C. B. J. Snyder, Municipal Bldg., Arch. and Engr.

N. Y., New York—The Consolidated Amusement Enterprises, c/o Arena Theatre, 8th Ave. and 40th St., is having plans prepared for the construction of a theatre on West 50th St. and 8th Ave. A steam heating system will be installed in same. Total estimated cost, $130,000. S. B. Eisendrath, 18 East 41st St., Arch. and Engr.

N. Y., Rochester—The E. W. Hamilton Manufacturing Co. plans to construct a 2 story, 55 x 195 ft. factory on Hallenbeck St. An electric power plant and machinery for the manufacture of paper boxes will be installed in same. Total estimated cost, $25,000.

N. Y., Syracuse—The Board of Contract and Supply will receive bids about January 1 for the construction of a 3 story school on South Alvord St. A steam heating system will be installed in same. Total estimated cost, $300,000.

N. Y., Syracuse—The Mills Oil Co., 263 Walton St., plans to build 4 or 5 buildings, including a boiler house, office building, stable, garage, storage tanks, etc. Total estimated cost, $200,000.

N. Y., New York—The Simrud Holding Corporation, 135 Broadway, will build several stores on a 74 x 94 ft. site on Fordham Rd. and Walton Ave. A steam heating system will be installed in same. Total estimated cost, $125,000. Work will be done by day labor.

N. Y., Syracuse—The Battery Service Co., Inc., 562 East Genesee St., will receive bids about March 1 for the construction of a 1 story battery service building on East Genesee St. Estimated cost, $50,000. M. E. Granger, Gurney Bldg., Arch. and Engr.

N. Y., Wards Island—The State Hospital Commission, Capitol, Albany, received bids December 17 for the installation of a heating system in the Manhattan State Hospital, here, from Leslie & Tracy, Inc., 5 Columbus Circle, $6300; Gillis & Geohegan, 537 West Broadway, $7180; Charles H. Darmstadt 352 West 43rd St., $7372. Contractors all of New York City.

N. J., Asbury Park—The Rydon Tire & Rubber Co., c/o E. A. Arend, Arch. and Engr., 105 West 40th St., New York City, will soon award the contract for the construction of a factory. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. J., New Brunswick—The city plans to issue $10,000 bonds for the installation of a water tube boiler in the pumping station and $8000 bonds for a water wheel, rotary pump, etc.

Del., Wilmington—The Daily News Co., 511 Market St., is having plans prepared for the construction of a 6 story publishing plant. A steam heating system will be installed in same. Dennison & Hirons, 477 5th Ave., New York City, Archs. and Engrs.

Md., Baltimore—Louis Miller, 5 Lloyd St., will receive bids about January 15 for the construction of a 2 story, 45 x 50 ft. dairy and cold storage building at 5-7-9 Lloyd St. Separate bids will be received for installing steam heating system, hand power elevator and refrigerators, etc. Total estimated cost, $50,000. G. R. Gallis, Melvin Ave., Catonsville, Arch.

Md., Crisfield—The McGready Memorial Hospital, c/o Dr. R. R. Norris, is having plans prepared for the construction of a 1 and 2 story hospital on Main St. A steam heating system will be installed in same. Total estimated cost, $100,000. H. G. Jory, 1409 Munsey Bldg., Arch.

Tenn., Memphis—Jones & Furbringer, Archs., Porter Bldg., wil soon award the contract for the construction of a sanitarium for tuberculosis patients at Oakville, including a power and heating plant, etc., for Memphis and Shelby Counties. Total estimated cost, $500,000. W. B. Cleveland, Chn., Board of Trustees.

Ohio, Bedford—The Board of Education will receive bids about February 1 for the construction of a 2 story, 80 x 164 ft. high school. A steam heating system will be installed in same. Total estimated cost, $200,000. Hamilton & Watterson, Guardian Bldg., Cleveland, Archs.

Ohio, Cleveland—The Citizens Savings & Trust Co. and the Union Commerce Bank

had plans prepared for the construction of a 20 story, 145 x 258 x 385 ft. bank and office building on East 9th St. and Euclid Ave. Four 300 h.p. boilers and stokers will be installed in same. Total estimated cost, $8,000,000. Graham-Anderson-Probst & White, Railway Exchange Bldg., Chicago, Engrs.

Ohio, Cleveland—The city received bids for the construction of a sewage disposal plant in the eastern section of the city, from the American Construction Co., Marion Bldg., $258,957; McHugh Brothers, West 37th St., $338,730; Masters-Mullen Construction Co., Electric Bldg., $400,486. One centrifugal pump with 1-2½ h.p. and 1-5 h.p. motors will be installed in same.

Ohio, Cleveland—The Hinkel Motor Truck Corporation, 6521 Euclid Ave., has purchased a site and plans to build a 2 story, 180 x 200 ft. auto salesroom and garage on East 71st St. and Carnegie Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. Whitworth & Johnson, Engineers Bldg., Archs.

Ohio, Cleveland—J. W. Holcomb, 916 Citizens Bldg., plans to build a 4 story commercial building at 3812 Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ohio, Cleveland—The Bender Auto Body Co. wil soon award the contract for the construction of a 1 story, 100 x 250 ft. factory on West 65th St. and Denison Ave. Two 250 h.p. boilers with stokers will be installed in same. Total estimated cost, $150,000. R. M. Hulett, Fire Bldg., Arch. Address H. Bender, c/o Northern Blower Co., Barberton Ave.

Ohio, Cleveland—A. B. Friedl, 3328 Vega Ave., has purchased a site on East 93rd St. and Kinsman Rd., and plans to construct a 3 story commercial building on same. A steam heating system will be installed in same. Total estimated cost, $100,000. W. S. Lougee, Marshall Bldg., Arch.

Ohio, Silver Lake—The village will soon award the contract for the construction of two 1 story, 17 x 17 ft. pump houses and is in the market for two deep well, 175 gal. per min. pumps, one pressure tank and seven 8-inch gate valves. Total estimated cost, $15,000. E. A. Tewksbury, Clk. R. Winthrop Pratt, Hippodrome Bldg., Cleveland, Engr.

Mich., Battle Creek—The Kellog Toasted Corn Flake Co. plans to construct a 3 story, 100 x 218 ft. dormitory for employes. A steam heating system will be installed in same. Total estimated cost, $100,000.

Mich., Detroit—The Board of Education, 50 Broadway, will soon award the contract for the construction of a 2 story, 84 x 134 ft. school building on Vancourt and Milford Aves., cost $250,000; also for the construction of a field school No. 1154, Agnes and Field Aves., $200,000, and Davidson School No. 1147, Roman Ave., near Davidson Ave., $200,000. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Archs.

Mich., Detroit—Louis Kamper, Arch., Book Bldg., will soon award the contract for the construction of a 1 story, 110 x 110 ft. pavilion on East Jefferson Ave. and Grand Blvd., for the Kling Products Co., 1424 East Jefferson Ave. A steam heating system will be installed in same. Total estimated cost, $70,000.

Mich., Detroit—The Associated Amusements Co., c/o Christian W. Brandt, Arch., Kresge Bldg., is having plans prepared for the construction of a 2 story, 120 x 135 ft. theatre on Hamilton Blvd. Steam heating equipment and a forced ventilation system will be installed in same. Total estimated cost, $250,000.

Mich., Detroit—The Board of Fire Commissioners received bids for the installation of heating, ventilating and plumbing systems in the proposed 2 story, 40 x 80 ft. fire engine house on 12th and La Belle Sts., from O'Connor Bros., 34 Roland Bldg., $9209; Irvine & Meier, 2289 Woodward Ave., $10,270; W. J. Rewoldt, Owen Bldg., $10,553.

Mich., Detroit—The Clayton & Lambert Manufacturing Co., Beaubien St., plans to construct a 1 and 2 story factory for the manufacture of automobile parts, along the Detroit Terminal Railway. Plans include a power plant. Total estimated cost, $500,000.

Mich., Detroit—The Columbia Motors Corporation, 1256 East Jefferson Ave., engaged Horace H. Lane, Arch. and Engr., Dime Bank Bldg., to prepare plans for the construction of a 2 and 3 story, 300 x 720 ft. automobile factory on Fort and Boyd Sts. Steam heating equipment will be installed in same. Total estimated cost, $600,000.

Mich., Detroit—Albert Kahn, Louis Kahn and Julius Kahn, Marquette Bldg., have purchased a site on Cass Ave. and Peterboro St., and will prepare plans for the construction of a 4 story, 130 x 185 ft. commercial building on same. Steam heating equipment will be installed in same. Total estimated cost, $400,000. Albert Kahn, Arch.

Mich., Eaton Rapids—The Board of Education engaged S. D. Butterworth, Arch., 432 Tussing Blk., Lansing, to prepare preliminary plans for the construction of a 2 story high school. Steam heating equipment will be installed in same. Total estimated cost, $200,000.

Mich., Grand Rapids—Willard M. Burleson, 148-150 Fulton St., E., engaged Osgood & Osgood, Archs., Herald Bldg., to prepare plans for the construction of an 11 story, 105 x 146 ft. sanitarium on Island St. and Jefferson Ave. Steam heating equipment will be installed in same.

Mich., Redford—The Michigan State Auto School, Woodward Ave., Detroit, is having plans prepared for the construction of eight buildings, including a 1 story, 80 x 150 ft. power house and pumping station. Total estimated cost, $2,000,000. Christian W. Brandt, Kresge Bldg., Detroit, Arch.

Ill., Chicago—W. G. Uffendel, Arch., 39 South St., will soon award the contract for the construction of a manufacturing plant, including a 2 story, 125 x 190 ft. main building, a 2 story, 47 x 95 ft. office building, and a 1 story, 47 x 66 ft. boiler house and garage, at 2701 Greenview Ave., for the Economy Fuse & Manufacturing Co., 328 West Kinzie St. A steam heating system will be installed in same. Total estimated cost, $150,000.

Ill., Chicago—Charles S. Frost, Arch., 105 South La Salle St., will soon award the contract for the construction of a 2 story, 150 x 175 ft. printing plant at 1101 North La Salle St., for the Uniform Printing & Supply Co., 351 West Chicago Ave. A steam heating system will be installed in same. Total estimated cost, $225,000.

Ill., Chicago—Holabird & Roche, Archs., 104 South Michigan Ave., will receive bids in January for the construction of a 3 story, 160 x 180 ft. hotel addition on Clark and Randolph Sts., for the Hotel Sherman Co., Hotel Sherman. Additions will be built to the present steam heating system in same. Total estimated cost, $500,000.

Ill., Jacksonville—The city plans to construct additions to the existing steam power plant. Estimated cost, $40,000. This work is in connection with the improvements to the waterworks system. C. M. Borchers, Mayor.

Wis., Rio—The city will soon award the contract for the construction of an 18 x 60 ft. power house and for furnishing one 15 h.p. engine, one 150 gal. deep well pump, one 10 in. well, 200 to 300 ft. deep, one 40,000 gal. elevator tank and one 80 ft. tower. Total estimated cost, $25,000. W. Colins, Clk. W. Kirchoffer, Madison, Engr.

Wis., Manitowoc—George Brothers, 913 South 8th St., have engaged W. J. Roueber, Arch., to prepare plans for the construction of a 3 story, 100 x 125 ft. theatre building on South 8th St. A steam heating system will be installed in same. Total estimated cost, $150,000.

Neb., Scribner—The Scribner Artificial Ice Co. plans to build an ice plant and an electric plant. Total estimated cost, $65,000.

Minn., Aitkin—The city received bids for furnishing electric light and waterworks equipment from J. G. Robertson, Wabash and Eustis Sts., St. Paul, $9489.

Minn., New Ulm—The city plans to construct a 90 x 90 ft. power plant. Estimated cost, $50,000. A. J. Mueller, Supt.

Minn., Duluth—F. G. Beamsley, Cashier, will receive bids until February 1 for the construction of a 2 story, 50 x 140 ft. bank and office building on Superior st. and 20th Ave., W., for the Duluth State Bank. A steam heating system will be installed in same. Total estimated cost, $75,000. Halstead & Sullivan, Palladio Bldg., Archs. and Engrs.

Minn., East Grand Forks—J. A. Noonan, Secy. of Independent School District No. 3, will receive bids until January 15 for the construction of a 3 story, 130 x 170 ft. high and grade school on Kiltson Ave. and 6th St. A steam heating and mechanical ventilating system will be installed in same. Total estimated cost, $375,000. Bert & Beck, Grand Forks, N. D., Archs. and Engrs.

Minn., Robbinsdale—The Board of Education will soon receive bids for the construction of a 2 story school. A steam heating system will be installed in same. Total estimated cost, $125,000. C. A. Garner, Clk. H. H. Livinston, Arch.

Minn., St. Paul—The Emporium Mercantile Co., Robert St., between 7th and 8th Sts., will soon award the contract for the construction of a 6 story, 145 x 160 ft. department store on 7th and Robert Sts. Separate bids for installing steam heating system will be received. Total estimated cost, $650,000. C. L. Pillsbury Co., 716 Capital Bank Bldg., Engrs. Buechner & Orth, 500 Shubert Bldg., Archs.

Tex., Houston—The Hulbert-Still Electric Co. received only bid for the construction of a 1 story, 75 x 126 ft. service station at McKinney and San Jacinta Sts., from Andrew Hess, 4630 Park Drive, $22,000.

Colo., Boulder—The University of Colorado will soon award the contract for the construction of a 4 story woman's dormitory with two wings, 1 story, 58 x 162 ft. and 1 story, 32 x 193 ft., on the campus. A Warren Webster steam heating system will be installed in same. Total estimated cost, $250,000. F. H. Wolcott, 526 Kittderge Bldg., Denver, Secy. of the Board of Regents. W. E. and A. A. Fisher, 337 Century Bldg., Denver, Supervising Archs.

Colo., Mineral Hot Springs—The Mineral Hot Springs Resort Co. plans to construct several buildings. An electric light plant will be installed in same. Total estimated cost, $100,000. W. N. Bowman, Central Bank Bldg., Denver, Arch.

Colo., Montrose—Montrose County plans to build a 3 story, 65 x 130 ft. court house. A vacuum steam heating system will be installed in same. Total estimated cost, $150,000. W. N. Bowman, Central Savings Bank Bldg., Denver, Arch.

Idaho, Challis—W. W. Adamson, hydro-electric engineer, Boise, has been granted authority by the Idaho State Public Utilities Commission to construct a hydro-electric plant and system here.

Ore., Bend—The Bend Water, Light & Power Co. has filed an application with the state engineer for permission to appropriate 50 second ft. of water from Tumalo Creek, for the development of 4225 h.p. The company also plans to construct dams and canal. Total estimated cost, $229,000.

Cal., Fresno—The Board of Education will soon award the contract for the installation of a heating system, etc., in the new John Muir, Arlington Heights, Webster, Longfellow and Kirk School buildings. J. R. Fontaine, Secy.

Cal., San Jose—The Board of Supervisors will soon award the contract for digging a well and installing a pump and motor at the County Almshouse. Total estimated cost, $7000. H. A. Pfister, County Clk.

Cal., Ventura—The Sespe Light & Power Co., Merchants Trust Bldg., Los Angeles, plans to build hydro-electric plants and irrigation projects on the Sespe and Pivu Rivers; 1st unit to include 2 reservoirs of 51,000 acre ft., 46,000 ft. power conduit, 3000 ft. pressure pipe line, 1000 ft. head, 10,000 kw. hydro-electric plant, to be increased to 18,000 kw. when 2nd unit is built; 2nd unit, 100,000 acre ft. storage reservoirs, 90,000 ft. conduit, 4000 ft. pressure pipe line 2300 ft. head, and 8000 kw. plant; 3rd unit, additional storage to deliver 100,000 acre ft. per annum for irrigation. Cost for preliminary surveys about $100,000. F. Buren, Pres.

Ont., Hagersville—D. N. Almas is in the market for two 5 h.p. electric motors in his proposed seed cleaning building.

Ont., Almonte—The taxpayers will vote on by-law to raise $25,000 for the purchase of the Wylie Electric Power Plant. About $10,000 will be spent in development. W. Watchorn, Engr.

Ont., Alton—The Beaver Knitting Mills, Ltd., are in the market for one 5 h.p. and one 3 h.p. 60 cycle, 220 volt single phase motor.

Ont., London—The Bell Telephone Co., 118 Notre Dame St., W., Montreal, plans to construct a 1 story, 60 x 80 ft. addition to the telephone exchange building here. The present steam heating system in same will be enlarged. Total estimated cost, $100,000. W. J. Carmichael, 29 Hospital St., Montreal, Arch.

Ont., Mallorytown—The Consolidated School Board is having plans prepared for the construction of a 2 story school. A steam heating system and an electric operated ventilating fan will be installed in same. Total estimated cost, $160,000. B. Dillen, King St., Brockville, Arch.

Ont., Newmarket—The County of York, 57 Adelaide St., E., Toronto St., is having plans prepared for the construction of a 3 story, 80 x 150 ft. industrial home on Eagle St. A vacuum steam heating system will be installed in same. Total estimated cost, $28,500. E. A. James Co., Ltd., 36 Toronto St., Toronto, Engr.

Ont., Toronto—The city will soon receive bids for the installation of four 3 stage capacity, electrically driven pumps. Estimated cost, $75,000. R. G. Harris, City Hall, Engr.

Ont., Sudbury—The High School Board plans to construct a 3 story high school. A steam heating and ventilating system will be installed in same. Total estimated cost, $200,000.

Ont., Windsor—J. & J. J. Allen, Allen Theatre, Richmond St., Toronto, will soon award the contract for the construction of a moving picture theatre. A steam heating and blower ventilating system, etc., will be installed in same. Total estimated cost, $200,000. C. H. Crane, 2325 Dime Bldg., Detroit, Mich., Arch.

CONTRACTS AWARDED

Mass., Cambridge—Lever Brothers Co., manufacturers of soaps, have awarded the contract for the construction of a 2 story, 86 x 134 ft. boiler house at their plant to the Stone & Webster Engineering Corporation, 147 Milk St., Boston.

Conn., Greenwich—The town has awarded the contract for the construction of a 2½ story, 143 x 155 ft. school at Greenville, to the Rangeley Construction Co., 56 West 39th St., New York City. A steam heating system will be installed in same. Total estimated cost, $250,000.

Conn., Hartford—The South School District has awarded the contract for the construction of a 3 story, 87 x 87 ft. school addition on Wethersford Ave., to Wise & Upson, 36 Pearl St. A steam heating system will be installed in same. Total estimated cost, $210,000.

Conn., Hartford—C. H. Talcott, 19 Woodland St., has awarded the contract for the construction of a department store to the Republic Fireproofing Co., 26 Cortland St., New York City. A steam heating system will be installed in same.

Conn., New Haven—Kusterer & Smith, 376 Yale Ave., have awarded the contract for the construction of a 6 story, 80 x 116 ft. and 60 x 80 ft. business buildings on Court St., to DeBussey-Kusterer Co., 116 Church St. A steam heating system will be installed in same. Total estimated cost, $100,000.

Conn., Waterbury—The American Pin Co., Waterville, has awarded the contract for installing a steam heating system in the proposed 4 story, 50 x 204 ft. brass factory at Waterville, to M. J. Daly & Sons, 543-555 Bank St., Waterbury. Total estimated cost, $200,000.

N. Y., Long Island City—The Queens Electric Light & Power Co., 347 Central Ave., Far Rockaway, has awarded the contract for the construction of a 1 story, 40 x 200 ft. garage on Reade and Jane Sts., to R. Keeves & Son, 309 Broadway, New York City. A steam heating system will be installed in same. Total estimated cost, $150,000.

N. Y., Long Island City—The Transport Service Co., 125 Harris Ave., has awarded the contract for the construction of a 5 story, 75 x 100 ft. garage and service station, on Harris and Sherman Aves., to L. Gold, 44 Court St., Brooklyn. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. Y., New York—The Lawyers Title and Trust Co., 160 Broadway, has awarded the contract for the construction of an 11 story, 50 x 106 ft. office building at 160 Broadway, to G. B. Beaumont, 286 5th Ave. A steam heating system will be installed in same.

N. Y., New York—George Backer, 20 East 32nd St., will build a 30 story, 100 x 162 ft. office, store and theatre building on 57th St. and 5th Ave. A steam heating system will be installed in same. Total estimated cost, $6,000,000. Work will be done by day labor

N. Y., New York—Fred T. Ley, 19 West 44th St., will build a 20 story office building on 42nd St. and Madison Ave. A steam heating system will be installed in same. Total estimated cost, $2,000,000. Work will be done by day labor.

N. Y., Syracuse—The Greenway Brewing Co. has awarded the contract for the construction of a 3, 5 and 7 story, 80 x 500 ft. garage on West Water St., to the Syracuse Bridge Co., University Bldg. A steam heating system, including two 80 h.p. boilers and fuel oil burners, will be installed in same. Total estimated cost, $250,000.

Pa., Philadelphia—Gomery & Schwartz, 128 North Broad St., have awarded the contract for the construction of a 6 story, 220 x 440 ft. sales and service building, on 24th and Market Sts., to M. J. O'Meara, 6421 Overbrook St. A steam heating system will be installed in same. Total estimated cost, $700,000.

Md., Cumberland—The George Washington Hotel Co. has awarded the contract for the construction of an 8 story hotel to the Wise Granite & Construction Co., American National Bank Bldg., Richmond, Va. Contract for installing heating system in same will be sub-let. Total estimated cost, $350,000.

Ohio, Cincinnati—The Ohio Butterine Co., 50 Walnut St., has awarded the contract for the construction of a 1 story, 18 x 90 ft. boiler house, to F. W. Foltz & Co. and the Detroit Steel Products Co., 1460 Penobscot Bldg., Detroit.

Ohio, Cleveland—The Association Building Co., c/o Dr. W. E. Power, Osborn Bldg., has awarded the contract for the construction of a 4 story, 86 x 240 ft. office building, on Euclid Ave. and East 93rd St., to the Crowell-Lundoff-Little Co., 5716 Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $300,000.

Ohio, Cleveland—The Parish-Pool Copper Co., c/o Paul E. Cleveland, Guardian Bldg., has awarded the contract for the construction of a 1 story, 150 x 500 ft. smelting and refining building on Clinton Rd., to A. W. Kilbourne Co., 6532 Euclid Ave. Two boilers will be installed in same. Total estimated cost, $300,000.

Ohio, Cleveland—J. W. Wilson, 450 Leader-News Bldg., has awarded the contract for the construction of a 4 story, 76 x 270 ft. apartment hotel, at East 96th St. and Euclid Ave., to Paul Bros., 528 Citizens' Bldg. A steam heating system will be installed in same. Total estimated cost, $400,000.

Ind., Indianapolis—The Cole Motor Car Co., 750 East Washington St., has awarded the contract for the installation of a heating system in the proposed 4 story, 179 x 225 ft. auto assembly factory, on Market and Davidson Sts., to Hayes Brothers Co., 236 West Vermont St. Total estimated cost, $300,000.

Mich., Detroit—The Board of Education, 50 Broadway, has awarded the contract for installing heating, ventilating and plumbing systems in the proposed 2 story, 150 x 211 ft. school on Maplewood and Spokane Aves., to Irvine & Meier, 2289 Woodward Ave., $81,682.

Mich., Detroit—The city has awarded the contract for the construction of seven mile sewer and pumping station and for furnishing equipment for same to C. A. Handyside, 833 Lathrop Ave., $26,600.

Mich., Detroit—H. C. Keywell, 501 Old Whitney Bldg., has awarded the contract for the construction of a 2-story, 38 x 115 x 190 ft. theatre on Grand River Ave., to Daniel Fidler, 242 Melbourne Ave. A steam heating boiler with forced ventilation equipment will be installed in same. Total estimated cost, $90,000.

Mich., Detroit—The La Salle Gardens Theatre Co., c/o C. W. Brandt, Arch., 1114 Kresge Bldg., has awarded the contract for the construction of a 2 story, 100 x 160 ft. theatre at La Salle Gardens, to Frank Farrington Co., Scherer Bldg. A steam heating system, consisting of boiler, motor-driven fan, etc., will be installed in same. Total estimated cost, $200,000.

Mich., Flint—St. Mathew's Parish has awarded the contract for the construction of a 2 story school on Beach St., to the Duboise Construction Co., 1519 North Saginaw St. A steam heating system will be installed in same. Total estimated cost, $150,000.

Mich., Lansing—The Atlas Drop Forge Co., 209 West Mt. Hope Ave., has awarded the contract for the construction of a 150 ft. extension to its steel storage yard and plant and for furnishing equipment, consisting of 3 heavy trip hammers, addition to furnace capacity, additional 300 h.p. boiler and traveling crane, to the Wisconsin Bridge & Iron Co., Penobscot Bldg., Detroit.

Ill., Chicago—The Channel Chemical Co., 58 East Washington St., has awardtd the contract for the construction of a 4 story, 150 x 300 ft. factory on Western Ave. and West 45th St., to Davidson & Weiss, 53 West Jackson Blvd. A steam heating system will be installed in same. Total estimated cost, $450,000.

Ill., Chicago—The Playerphone Talking Machine Co., 338 North Kedzie Ave., has awarded the contract for the construction of a 3 story 110 x 160 ft. phonograph factory on Lake St. and Kildare Ave., to J. C. Stellwagen, 1583 Clybourn Ave. A steam heating system will be installed in same. Total estimated cost, $110,000.

Ill., Chicago—The Fulton Market Cold Storage Co., c/o J. Byfield, Pres., Hotel Sherman, has awarded the contract for the construction of a 10 story, 250 x 325 ft. cold storage warehouse on Fulton and Morgan Sts., to Blome Sinick Co., 139 North Clark St. Estimated cost, $4,000,000. Noted Aug. 26.

Mo., St. Louis—The Bridge & Beach Manufacturing Co., 1st and Valentine Sts., has awarded the contract for the construction of seven buildings, including a 1 story, 25 x 60 ft. boiler house, on Union and Belt Sts., to the Fruin-Colnon Contracting Co., Merchants Laclede Bldg. Total estimated cost, $430,000.

Ont., Toronto—W. Davies Co., 29 Queen St., W., has awarded the contract for the construction of a 4 story, 36 x 103 ft. store and office building to the Corswell Construction Co., 58 Wellington St. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ont., Toronto—F. R. Pember, Jones Ave., has awarded the contract for the construction of a 600 ton circular coal handling plant to J. B. Nicholson, Ltd., Excelsior Life Bldg. Estimated cost, $30,000.

Ont., Peterborough—The Board of Education has awarded the contract for the construction of a 2 story school building to Richard Sheeby, 751 George St., $167,963. A steam heating and ventilating system will be installed in same.

Ont., Weston—The Canada Cycle & Motor Co. has awarded the contract for the construction of a 2 story, 80 x 160 ft. bicycle factory addition on Weston Rd., to the John V. Gray Construction Co., Confederation Life Bldg., Toronto. A vacuum steam heating system will be installed in same. Total estimated cost, $150,000.

Ont., Kitchener—The Dominion Tire Co., 149 Strange St., has awarded the contract for the construction of a 4 story, 80 x 250 ft. rubber tire factory on King St., W., to the MacKinnon Steel Co., Sherbrooke, Que. A steam heating system will be installed in same. Total estimated cost, $300,000.

PRICES--MATERIALS--SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		75c. per ft.
Common, 2½-in.		40%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.50	$0.33	$0.22

Steam—Discounts from List

First grade.....30% Second grade.....40% Third grade.....45%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition.....65% Best grade.....35%
Standard.....50%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	35%	
St. Louis	40%	30%
Chicago	20%	10%
Birmingham	15%	20%
Denver	30%	20%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.50
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.10
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin. Ft.	Thickness	Price Per Sq. Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

For low-pressure heating and return lines: 4-ply 58% off; 3-ply 60% off; 2-ply 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	6.6	6.7	8½	13
Fiber or sponge	8	10	8.6	13	8½	18
Transmission	7	9	8.1	13	8½	15
Axle	4½	6	4.8	4.75	4½	5½
Gear	4½	9	6.1	7.5	8½	8
Car journal	22(gal.)	21(gal.)	4.7	4.7	8½	15½

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	13.00	11 00 to 13 00	14 00	11.00 to 14.00
Colored mixed	9.00 to 12.00	8.50 to 11.00	11.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$52.00	$58.00
Chicago	43.00	45.00

LINSEED OIL—These prices are per gallon:

	New York		Chicago	
	Current	One Year Ago	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$1.90	$1.59	$2.09	$1.90
5-gal cans	2.07	1.84	2.34	2.00

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	14.00	15.50	14.00	14 50	14 00	14.00
25- and 50-lb. kegs	14.25	15 70	14 25	14 75	14.25	14 25
12½-lb. keg	14 50	16.00	14.50	15.00	14.50	14.50
1-lb. cans	16.00	17.50	.....	.....	16 00	16.00
5-lb. cans	17.00	18.50	.....	.....	17.00	17.00

500 lb. lots less 10% discount; 2000 lb. lots less 10-2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	40%	55%	50%
Tinned	40%	55%	50%

Boiler rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York....$5.00 Cleveland....$4.00 Chicago.....$4 87 Pittsburgh....$4.72

Structural rivets, same sizes:

New York....$5.10 Cleveland....$4.10 Chicago.....$4.97 Pittsburgh....$4.83

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$80-90	at Chester, Penn.
Chrome cement	net ton	45-50	at Chester, Penn.
Clay brick, 1st quality fireclay	net M	35-45	at Clearfield, Penn.
Clay brick, 2nd quality	net M	30-35	at Clearfield, Penn.
Magnesite, dead burned	net ton	32-50	at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90	at Chester, Penn.
Silica brick	net M	41-45	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.

Birmingham—Silica, $46.50-$51.50 per M; fire clay, $42.00-$45.00 per M; magnesite, $80 per ton; chrome, $80 per ton.

Chicago—Second quality, $25 per ton

Denver—Fire clay, $11 per ton.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	90 00	95.00	70.00	93 00	60.00	96.00
Commercial	55.00	50.00	16.50	23.00	13.00	25.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$21.26	$19 00
Cleveland	20.00	20 00
Chicago	16.50	19.00

In coils an advance of 50c. is usually charged.

SHEETS—Quotations are in cents per pound in various cities from warehouse; also the base quotatfons from mill:

	Mill	New York			
	Carloads Pittsburgh	Current	One Year Ago	Cleveland	Chicago
No. 28 black	$4.35-4.85	$7.00-8.00	$6.52	$5.77	$6.00
No. 26 black	4.25-4.75	6.90-7.90	6.42	5.67	5.90
Nos. 22-24 black	4.20-4.71	6.85-7.85	6.37	5.62	5 85
Nos. 18-20 black	4.15-4.65	6.80-7.80	6.32	5.57	5.80
No. 16 blue annealed	3.75-3.20	6.02	5.72	5.17	5.02
No. 14 blue annealed	3.65-3.10	5.92	5.62	5.07	4.92
No. 10 blue annealed	3 55-4.00	5.50-6.00	5.52	4.97	4.82
No. 28 galvanized	5.70-6.20	7.50-9.00	7.77	7.12	7.25
No. 26 galvanized	5.40-5.90	7.20	7.47	6.82	6.95
No. 24 galvanized	5.25-5.75	7.05	7.32	6.57	6.52

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Steel	Black	Galvanized	Iron	Black	Galvanized
⅛, ¼, and ⅜	50½%	24%	⅛ to 1¼	30%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			

LAP WELD

2	50½%	35%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	46½%	29%	½ to 1¼	39½%	24½%
½	51½%	39%			
¾ to 1¼	55½%	43%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	48½%	37%	2	33½%	20½%
2½ to 4	51½%	49%	2½ to 4	35½%	23½%
4½ to 6	50½%	39%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¼ to 3 in. steel butt welded	47%	31%	43½%	34½%	57½%	44%
2½ to 3 in. steel lap welded	42%	27%	45½%	39½%	53½%	41%

Malleable fittings. Classes B and C, from New York stock, sell at list +12½%
Cast iron, standard sizes, 10-5% off.

BOILER TUBES—The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	40½	3½ to 4½ in.	15½
2½ to 3½ in.	30½	3 to 3½ in.	1
2½ in.	24	2½ to 2¾ in.	+ 1
1¼ to 2 in.	19½	2 to 2½ in.	16
		1¼ to 1½ in.	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$327	1¼ in.	$207
1¼ in.	267	2 to 2½ in.	177
1½ in.	257	2¾ to 3½ in.	167
1¾ in.	207	4 in.	187
		4½ to 5 in.	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiations.

ELECTRICAL SUPPLIES

RMORED CABLE—

B.& S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$184.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	Net List
Coils to 1,000 ft.	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size, red seal, Columbia or Ever Ready:

	Each, Ne
Less than 12	$0.40
12 to 50	.39
50 to 125 (bbl.)	.36
125 (bbl.) or over	.34

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

Size, In.	Conduit Black 1,000 Ft. and over	Conduit Galvanized 1,000 Ft. and over	Elbows Black 100 and Over	Elbows Galvanized 100 and Over	Couplings Black 100 and Over	Couplings Galvanized 1,000 and Over
¼	$71.15	$76.25	$17.04	$18.18	$5.38	$5.74
⅜	71.15	76.25	17.04	18.18	6.25	6.70
½	93.96	100.86	22.23	23.93	8.97	9.57
¾	138.39	149.09	33.19	35.41	11.66	12.44
1	187.91	201.71	42.62	45.31	16.10	17.12
1¼	224.08	241.18	56.82	60.62	19.89	21.15
1½	302.29	324.49	104.17	110.77	26.52	28.20
2	477.95	513.05	170.46	181.26	37.88	40.28
2½	625.00	670.91	454.56	483.36	56.82	60.42
3	779.24	834.44	1,003.82	1,067.42	75.76	80.56
3½	945.03	1,010.43	1,160.08	1,223.57	94.70	100.70
4						

5% cash 10 days.
From New York Warehouse—5% cash.
Standard lengths rigid, 10 ft. Standard lengths flexible, 100 ft. Standard lenghts flexible, ¼ to 2 in., 50 ft.

CONDUIT, NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
¼	250	$0.05½	
⅜	250	.06	
½	250	.09	
¾	200	.12	
1	200	.15	Coils.....55% off
1¼	150	.18	Less coils...45% off
1	100	.25	
1½	100	.33	
1¾	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are the net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. P.	$0.24
D. P. M. L.	.11	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	....
T. P. S. B.	.81	1.80	....
D. P. D. B.	.78	2.10	....
T. P. D. B.	1.35	3.60	....
T. P. to D. P. D. B.	.90	2.52	....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$16.75
No. 16 cotton twisted	22.00
No. 18 cotton parallel	19.80
No. 16 cotton parallel	25.75
No. 18 cotton reinforced heavy	30.00
No. 16 cotton reinforced heavy	36.50
No. 18 cotton reinforced light	23.40
No. 16 cotton reinforced light	27.50
No. 18 cotton Canvasite cord	26.00
No. 16 cotton Canvasite cord	28.50

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp to 100-amp.	50	.90
110-amp to 200-amp.	25	2.00
225-amp to 400-amp.	25	3.60
425-amp to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount:	
Less than 1-5th standard package	30%
1-5th to standard package	40%
Standard package	52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75 C
0-30 ampere, less than standard package	6.00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shape Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.35	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annua contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current tape No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York

No.	Soild Single Braid	Solid Double Braid	Stranded Double Braid	Duplex
14	$12.00	$14.00	$13.90	$25.00
12	13.25	15.70	18.05	30.70
10	18.30	21.00	23.85	41.50
8	25.54	28.60	32.70	56.77
6	.....	.....	51.40	.....
4	.....	.....	70.00	.....
2	.....	.....	101.80	.....
1	.....	.....	131.86	.....
0	.....	.....	160.00	.....
00	.....	.....	193.50	.....
000	.....	.....	235.20	.....
0000	.....	.....	288.60	.....

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap Key, Each	Keyless, Each	Pull, Each	¾ In. Cap Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+20%
1-5th to standard package	+10%
Standard package	−15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.& S. regular spools (approx. 8 lb.)	36c. lb.
No. 18 B.& S. regular 1-lb. coils	37c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb., 50c. lb., 100 lb. lots	55c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb., 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole Each	Fore Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:	
Less than $10.00 list value	+ 5%
$10 to $25 list value	− 8%
$25 to $50 list value	−14%
$50 to $200 list value	−20%
$200 list value or over	−25%